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HIGHER TECHNOLOGICAL EDUCATION

DURING the discussions on science and industry in the House of Lords on June 11 and 12, considerable attention was given to the proposal to build in Great Britain a technological institute of university standing. The speeches were noteworthy for their practical approach, and a most interesting feature was the change in emphasis on certain aspects. In view of the extent to which the scientific and academic world is divided on the issue of a technological university, the welcome which Lord Woolton's statement received in the House of Lords is impressive. Although he intimated that the Government has not decided exactly how the proposal is to be implemented, the importance of early action was uniformly stressed in the debate, as was the necessity of associating the new institution with the University Grants Committee and ensuring that it has the same freedom and independence as the universities themselves enjoy.

Lord Stamp's suggestion that the University Grants Committee is already too over-burdened to undertake such responsibilities, and that a parallel committee is required to cover technological education, did not imply dissent from this insistence on the academic independence of the new institution. He too, moreover, emphasized the distinction between higher technological education and technical education ; indeed, a feature of the debate was the doubt expressed as to the possibility of technological and technical education being carried out in the same institutions, and the necessity for the production of technologists and technicians to be in balance. Lord Falmouth, for example, suggested that in some industries forty technicians are required for every high-grade technologist.

On such issues discussion is obviously handicapped until the Minister of Education makes the promised announcement of the Government's proposals for increased assistance for selected technical colleges and courses, and it appears from her answers to questions in the House of Commons on June 17 and 19 that this will not be forthcoming for a few weeks. From the second reply it appears that only the terms are then to be announced, and that it will be for the colleges themselves to apply for increased assistance. It does not follow from the wording of this reply that the selection is to be made by any one body responsible for the expansion of higher technological education as a whole, and for keeping it in balance with that of university education.

Misgivings as to whether the new proposals will result in the promised aid being spread too thinly over a large number of institutions, instead of being concentrated on four or five carefully selected having regard to national needs and resources, as was urged in this debate and elsewhere, are thus bound to persist at least until the Minister makes her statement. No doubt the observations made in this debate will be carefully noted by Lord Woolton and Lord Cherwell, who should be able to ensure that they receive due consideration when the Government

makes its decision. Moreover, the debate should at least help to dispel any misgivings the universities themselves may entertain that the expansion of technological education is being conceived on narrow lines. The need for well-educated men and women was generally recognized, and there was a general agreement that technological education should develop in close association and in balance with the expansion of the universities themselves. Lord Wavell, indeed, frankly challenged the universities to strenuous thinking and perhaps adaptation of their constitutions to meet this need for maintaining a supply of scientific men able to sustain our wealth and influence in the world to-day and yet preserve all our old classical and liberal traditions of learning.

Due weight was given in this debate to the practical problems which attend the establishment of a new technological institution or the expansion of the technological departments of existing universities—the competition for staff and the availability of sufficient teaching staff of the highest calibre. The efficient use of costly equipment is another factor, as is the financing of research involving the use of such apparatus. It was appreciated, too, that the benefits of expansion accrue only slowly: Lord Hankey pointed out that although we have doubled the numbers of science graduates in the universities in five years, it will be some time before the increased numbers have their full effect.

The agreement in this debate on the importance of a wide and full education for the scientist and technologist was accompanied by a remarkable amount of support for the suggestion, which has frequently been made lately, that some reconsideration by the universities of the present distribution between science and arts faculties is required. It was argued in an article in *The Economist* of May 24 that a case appears to exist for some shift in the university population towards a greater emphasis on science and technology, at the expense of the arts. It is implicit in Sir John Cockcroft's article "Technology in the Universities" in the *Universities Quarterly* of May, in which he suggests that a further 50 per cent increase in the number of technological students is possible without upsetting the balance of the universities; Prof. R. S. Edwards reached a similar conclusion in a survey of the future of industrial research and development in Great Britain contributed to *Lloyds Bank Review* last January.

In the Lords debate, Lord Wavell in particular emphasized that by insisting on a broad training for scientific men, a programme involving a thirty per cent increase in graduates trained predominantly in science could be achieved with little or no disturbance of the balance of professors or extra laboratory space. The question is manifestly one calling for examination, and may well point the way to a solution of some of the difficulties to which the Advisory Council on Scientific Policy pointed in its recent report on man-power. It could scarcely fail to increase the supply of administrators with knowledge of science, and might also help to overcome the prejudices which at present appear to hinder some of the ablest talent in the schools turning towards a career in science. Similar views were expressed by Sir John Cockcroft in the *Universities Quarterly*. Welcoming the proposal for a new technological institution of university rank, Lord Waverley urged that it is also necessary to raise a few selected colleges of technology to university rank, and to detach them from the present system of technical education and place them under the University Grants Committee. The remaining technical colleges should be encouraged to develop their work in association with the great local industries. Sir John Cockcroft specified several colleges as suitable for development to university status, preferably in association with university departments, and he also advocated at least one really large college of technology, on the grounds that it would provide the needed increased facilities for post-graduate work. He also believed that the quality of university teaching in technology should be still further improved.

Sir John claimed that by these means the universities could make a further substantial contribution to technological education without increasing appreciably their total numbers. Besides more encouragement and funds for postgraduate research, an improvement in the numbers and status of professorial staff in some of the colleges of technology would be required; but the changes could be made at a cost which need be no more than a fraction of one per cent of our total expenditure on research and development.

Returning to the House of Lords debate, it undoubtedly reflected very fairly the trend of representative opinion on the question of technological education and its bearing on the future of Great Britain. Possibly the debate did not fully reflect the division of opinion in academic circles on one particular issue —that of the technological university—and only Lord Waverley appeared to raise the question of research at the development stage. Lord Falmouth, however, commented, as frankly as Prof. Edwards in the article referred to above, on the bearing of our present taxation policy on industrial research and development. The fact so generally recognized in the debate that the expansion and improvement of technological education in present circumstances must demand sacrifices elsewhere is the decisive reason for insisting that its development should be entrusted to some one body competent to handle it with due regard to that of the universities themselves, and of making the appropriate representations to ensure that technical education itself is kept in balance and enabled to supply the necessary numbers of technicians.

Nor is this a matter for the Government alone; whatever body, whether the University Grants Committee or the Advisory Council on Scientific Policy, is made responsible for handling it, will depend very largely on the co-operation of industry itself if the policy is to have full effect. It is not merely that, as Lord Chorley remarked in the debate, hostility to the university graduate still lingers in some sections of industry, and a major problem in reducing the discrepancy between the output per man in Britain and in the United States (which Mr. P. Hoffmann, formerly the Economic Co-operation Administrator, recently estimated as now two and a half times that

of Western Europe) is to convey to the small firms generally a sense of the urgent need for a technological approach to the problems with which they are confronted. That, indeed, must be a first step before there can be any significant change in the situation in which, after allowing for the differences in the sizes of the labour forces and the population of the two countries, the United States are turning out and employing three times as many scientists and technologists as Great Britain. It should be taken while the plans for the expansion of technological education are being completed and put into operation, so that the demand is effective by the time the increased output of trained men is available.

The debate in the House of Lords gives a clear lead to the Government as to what is required and the urgency of the whole matter. Nor was the Government left in any doubt that the measures required will be costly, and that sacrifices will have to be made elsewhere in the national economy if anything effective is to be achieved. Success will not be attained by taking some of the £20 millions already allotted to the universities for the next quinquennium. On this point Lord Cherwell did not give the assurance for which Lord Falmouth had asked. None the less, the Government cannot fail to have noted the perspective in which the whole problem was placed in this debate, or the way in which it was urged that science and invention are unlikely to be harnessed as effectively as our international position demands while fiscal policy curbs so strongly pertinacity and initiative in industrial development. That the debate contributed little that is new does not make it any the less useful a stimulus to the constructive thought required on the part of Government, industry and the universities if an adequate policy for technological education and research is to be formulated and effectively implemented. The debate is also valuable for its contribution to the task of public education, which the Advisory Council on Scientific Policy has recommended as a prelude to the formation of a climate of opinion favourable to the effective utilization of science in industry.

THE AMERICAN GEOGRAPHICAL SOCIETY

Geography in the Making

The American Geographical Society, 1851–1951. By John Kirtland Wright. Pp. xxi+437+31 plates. (New York: American Geographical Society, 1952.) 5 dollars.

THE nineteenth century was a time of great voyages and striking discoveries in all parts of the world. Huge areas of Africa, Asia, America and most of the polar regions were unknown and were a lure to adventurers, prospectors, traders and colonists. The civilized world was eager for knowledge of remote and unfamiliar lands and seas. Both in Britain and the United States, wealthy men were willing to subsidize journeys that promised gain in trade and raw materials. Africa and the polar regions were special attractions to both sides of the Atlantic. The natural outcome was the grouping of these interests into geographical societies in both London and New York.

In its early days, the American Geographical Society was interested mainly in exploration, statistics and descriptions of new lands. Patrons were not wanting, and the Society grew in numbers and influence, and as quickly gave the impetus to American geography. It has had only some three directors in its life-time, and each has made marked impressions on its activities, especially the twenty years of Isaiah Bowman, who was appointed early in the First World War. Bowman tried to apply geographical thought to outstanding human problems. His was no narrow view of geography, and he was not concerned with defining and limiting its scope. One of his avowed aims was an intensified search for authors who would present geography in its diversity. He changed the *Bulletin*, the Society's publication, to the *Geographical Review*, broadened its scope and increased its originality, without reducing its value. In fact, it became one of the chief geographical publications of the day and did much to raise the value of the geographical outlook and the dignity of the subject. But Bowman did more. He started the preparation of research monographs covering a wide field, and, most ambitious of all, the Million Map of Latin America. This was in conformity with the International Million Map and covered 107 sheets. It took twenty-five years to compile the first edition, of which 61 sheets were published during Bowman's administration. The cost was close on half a million dollars.

The Society has no narrow outlook; it has adhered to a few simple leading principles, and has never accepted the doctrine that a sharp line should be drawn between geography and what is not geography, or that its interests should be confined within an academic definition of the subject. It may well claim to have raised the standard of achievement in geography in the past hundred years.

The book under notice, a heavy volume of nearly 500 pages, goes into details concerning the work of most of the officials connected with the Society. It is copiously documented, has a long list of publications and is illustrated by many portraits of officials and other geographers. It is a story of American geography as well as the life-history of the American Geographical Society [see also p. 98].

EXTENSIONS OF THERMODYNAMICS

Thermodynamics of Irreversible Processes

By Prof. S. R. de Groot. (Selected Topics in Modern Physics, 3.) Pp. xvi+242. (Amsterdam: North-Holland Publishing Co.; New York: Interscience Publishers, Inc., 1951.) 17.50 f.

THE laws of 'reversible' thermodynamics lead to relationships between the 'equilibrium' properties of substances, for example, specific heats, compressibility, coefficient of expansion, etc., such relationships following from the consideration that small disturbances of an assembly in equilibrium can, in principle, be regarded as reversible. These deductions can ultimately be justified by appeals to statistical mechanics—that is, they are consequences of the fact that a macroscopic assembly contains a very large number of atoms. It was long regarded as certain that similar relationships between transport coefficients, for example, heat conductivity, diffusivity, etc., could be found from general con-

siderations, without the development of detailed theories for each effect.

This book discusses three distinct lines of approach to this question. Most of it is concerned with developing the consequences of the general results found by Onsager[1] in 1931, which are themselves consequences of 'microscopic reversibility' (sometimes referred to as the principle of detailed balancing). The fact that the equations of classical and quantum mechanics are symmetrical as between past and future time is shown to lead to general relations between the transport coefficients quite independent of their detailed mechanisms. Among many other results one can, in this way, give a proper derivation of Kelvin's thermoelectric relations, which, as Kelvin fully realized, cannot be deduced rigorously by the 'text-book' method of using reversible thermodynamics (because of the impossibility of finding conditions in which the irreversible effects associated with Joule heating and thermal conduction are both small).

Before the discovery of the Onsager relations, some progress in the theory of transport effects had been made along a somewhat different line. The idea was that entropy could be defined for an assembly 'not quite in equilibrium', the irreversible processes leading to a 'creation of entropy' at each point in the assembly, while the reversible processes implied a transfer of entropy from place to place. Such treatments were found to give satisfactory results for small temperature and pressure gradients, but it was not known how far they could be regarded as valid, as they must clearly break down for very large departures from equilibrium. Some indication of the limits of validity of such theories had become very desirable. For gases a quantitative answer has been found by Prigogine, by comparing the results of this 'extended thermodynamics' with those of the Chapman–Enskog kinetic theory—the conclusion being that the two theories agree as far as the second approximation of the latter theory, but that the expected breakdown of 'extended thermodynamics' occurs for cases where the third approximation is significant. The book should serve a useful purpose in directing attention to this interesting work, but a fuller discussion would have been welcome.

A third line of approach is the study of 'stationary states', typified by the flow of a gas through a nozzle or throttle-valve, the pressures and temperatures remaining steady at both ends. The text-book treatments of the Joule–Thomson effect and the 'wire-drawing' of steam illustrate how one can make quantitative deductions about such 'open' assemblies, again granted the possibility of defining entropy. The study of such 'open' assemblies is likely to be of very great importance in biological problems.

A typical biological process is the conversion of carbon dioxide and water into carbohydrates with the aid of sunlight. One may think of the living cells as being supplied steadily with raw material and energy, the products (for example, carbohydrates and oxygen) being carried away at an equivalent rate. Such an assembly is entirely different from the 'closed' assembly normally considered in classical thermodynamics, and it is only gradually coming to be realized that quantitative deductions about such an 'open' assembly can be made without detailed knowledge of the very complex chemical reactions which take place in it. It is a pity that the biological aspect of 'open' assemblies does not receive more attention in the book. (It gets less than a page.)

The book is very nicely printed and has only a very occasional error of spelling or grammar. The index, bibliography and list of symbols have obviously been prepared with very great care, though there is sometimes difficulty in tracing the reference relevant to a specific point in the text. The author implies that he found it impracticable to give 'footnote' references. I feel that a disproportionate amount of space has been given to the Onsager relations, important though these are, and that more might have been devoted to the other two topics. In a future edition, it might also be worth including a discussion of the paradox that macroscopically irreversible effects do occur, even though the basic processes are microscopically reversible. This matter has been satisfactorily dealt with in a number of published papers, but the time seems ripe for dealing with it in a book.

This book is likely to remain a standard work of reference for some time to come.

H. N. V. Temperley

[1] Onsager, L., *Phys. Rev.*, **37**, 405, and **38**, 2265 (1931).

RECENT PROGRESS IN PHYSICS

Reports on Progress in Physics

Vol. 14 (1951). Pp. iv+412. (London: Physical Society, 1951.) 50*s*. net; to Fellows, 27*s*. 6*d*. net.

Vol. 14 of the "Reports on Progress in Physics" contains eleven articles, four of which deal with optics, three with nuclear physics, two with meteorology, one with microwave spectroscopy and one with the application of nuclear physics in medicine. The emphasis is on recent advances in the various subjects; but, as is customary in the "Reports", a mere listing of the subject-matter of recent research papers is carefully avoided. Each report is a model monograph, and enough background material is introduced to lead the reader by stages to an appreciation of the new advances or of the present established position of the particular branch of physics discussed.

In optics, a brief but important article by W. C. Price on recent advances in ultra-violet absorption spectroscopy deals with the development of new detectors, new sources and improved types of instrument, and, on the theoretical side, with the interpretation of ultra-violet spectra. Though the presence of an emission spectrum of the night sky has been known for a long time, it is only recently, and particularly since the end of the Second World War, with the introduction of improved instruments, that progress has been made in the investigation of the spectrum of the airglow and the aurora. This topic is the subject of a report by A. B. Meinel, of the Yerkes Observatory, University of Chicago. It is interesting to note that some progress has been made in assigning a height to each emission, a matter of some importance in the study of the physics of the upper atmosphere.

The optical properties of thin films, interference filters, the interferometric study of surface structures, Fabry–Perot étalons, interference refractometers and interference microscopes, form the main topics of discussion in the comprehensive report by H. Kuhn on new techniques in optical interferometry. The recent important advances and applications of this branch of physics, as exemplified by the work of Prof. S. Tolansky and others, need no emphasis; but Kuhn's survey, together with his references to new light sources and interferometric methods suit-

able for measurement of standards of length, is to be commended.

Finally, in this series of reports on optical phenomena, a historical survey of the diffraction theory of aberrations is given by E. Wolf, in which are traced the development of the subject from the early researches of Airy on an aberration-free image and the important advances made since 1940. This is the first article on the diffraction theory of aberrations to be published in the "Reports". However, as the theory is concerned with the study of images formed by actual optical instruments, it is of considerable practical, in addition to theoretical, importance and well merits a detailed report.

The selection of subjects to be included each year under the heading of nuclear physics must be very difficult, for the volume of literature on this branch of physics continues to be extremely large. For Vol. 14, angular correlations in nuclear reactions, nuclear interactions of cosmic rays, and nuclear effects in atomic spectra are chosen for individual reports. As in several other branches of physics, there is scarcely a problem in experimental nuclear physics the solution of which does not involve the measurement of an angle, and in his article on angular correlations M. Deutsch deals with the basic physical processes, experimental techniques and results of many experiments designed to study properties of nuclear energy states. The detailed and informative report which follows, by G. D. Rochester and W. G. V. Rosser on types of nuclear interaction, the properties of nuclear interacting particles and the correlation of nuclear events in the atmosphere and in condensed matter, is best summarized by quoting from the conclusion: "The general picture which emerges is one of rapid progress in the accumulation of empirical facts but little advance in our fundamental theoretical concepts. . . . Much remains then to be done, but the prospects are exciting. If the progress of the past few years can be maintained the coming years will see further rapid advances in this field of research and a solution of many of the problems which still baffle the nuclear physicist". The report by E. W. Foster on nuclear effects in atomic spectra is concerned mainly with results of optical investigations of hyperfine structure, particularly of isotope structure, and a description is given of recent work on the nuclear mass effect in helium. The subjects discussed are all receiving considerable attention by research workers at present, and it is interesting to read that the author considers that the appearance of improved experimental data and theoretical treatment is imminent.

The microphysics of clouds, by B. J. Mason and F. H. Ludlam, and a critical survey by N. C. Gerson of ionospheric temperatures are the two reports dealing with meteorology. In the first, microphysical processes—condensation, droplet growth, ice crystal formation, etc.—are mainly considered, and the results of recent experiments on the supercooling and freezing of water and on the behaviour of ice-forming nuclei are examined. The possibilities and limitations of methods of producing rain by artificial stimulation, a subject of general interest, are briefly discussed. The second report is a critical review of the relations which have been proposed between temperature and the various ionospheric parameters and of the methods for determining temperatures at altitudes of 100–400 km. The author concludes that there are considerable deficiencies in current knowledge, and meteorologists and physicists will be interested to read what these are and how they may be overcome.

The remaining two reports in Vol. 14 are perhaps the most appealing, one—anomalous fine structure of hydrogen and singly ionized helium, by W. E. Lamb—because it deals with microwave spectroscopy, a subject still in its infancy, and the other, some applications of nuclear physics in medicine, by W. V. Mayneord, because of its wider interest. In the former, not only is a clear and concise description given of the work, both experimental and theoretical, of Lamb, Rutherford and Skinner in which microwave methods are used to establish deviations from the Dirac theory of the fine structure, but also a brief review is made of the status of the theory prior to 1947 so that the non-specialist in this field may fully appreciate the problem that has to be tackled.

Vol. 14, like its immediate predecessor, is under the general supervision of the Papers Committee of the Physical Society, and the Committee, together with the executive editor, Dr. A. C. Stickland, are to be congratulated for the excellence of their publication. The criticism, made in the review of Vol. 13, of the absence of abstracts to reports does not now apply to Vol. 14, all the reports in which have useful contents lists and abstracts. S. WEINTROUB

PARASITISM AND SYMBIOSIS

Parasitism and Symbiosis

By Maurice Caullery. Translated by Dr. Averil M. Lysaght. (Textbooks of Animal Biology.) Pp. xii+340. (London: Sidgwick and Jackson, Ltd., 1952.) 35*s*. net.

THE second French edition of this book was reviewed in *Nature* (**167**, 495; 1951), and in that review the hope was expressed that it might be translated into English, a request for which had prompted Prof. M. Caullery to revise his book. The English edition is now available in the shape of this attractive and well-printed book, and the translator, Dr. Averil M. Lysaght, has done her work so well that everyone interested in this fascinating subject will be grateful to her for the care she has bestowed upon it.

The outstanding feature of the book is its synoptic, biological view of the two ways of life with which the work is chiefly concerned. The first three chapters deal with commensalism and with the transitions between this and inquinilism and parasitism. Seven chapters on parasitism follow, and the book concludes with three chapters on symbiosis. It is difficult to say which of these three sections is the most interesting. The author finds no natural distinction between commensalism, parasitism and symbiosis, and considers that these are "only categories created by us", which cannot, once they have been analysed, be delimited. "Under varied aspects they are only manifestations of the struggle for life." Those associations which have permitted the existence and perpetuation of the associated organisms have survived. Many other associations must have arisen, but have not been able to persist. The variety of structural and physiological changes shown by the successful associations are described in considerable detail, and many complex problems requiring further study by modern methods are indicated.

In parasitism these problems are numerous and intricate. This book leaves many of them out,

because it purposely omits discussion of bacteriology and the important problems of immunity, which are discussed in other works. An adequate discussion of these aspects of parasitology would, indeed, have been impossible in a book of this size and would have defeated the author's admirable purposes. In symbiosis the problems requiring investigation are, in some respects, even more interesting. The pages of the book that deal with symbiotic organisms associated with insects—for example, with the possible part played by photogenic bacteria in the production of luminescence and with symbiosis among plants—provide fascinating material for extensions of research designed to settle the controversies discussed.

I have not noticed any misprints and only one important error has been noted, namely, the statement on p. 189 that the warble fly penetrates the host "under the same conditions as" the bot fly. This error dies hard. It has been clearly shown that the warble fly larva penetrates the skin of cattle and does not enter through the mouth, as do the larvæ of the bot fly.

A word about the bibliography is necessary. This, the author explains, is not meant to be comprehensive and, indeed, it could, in a book of this size, scarcely be so. The list of 598 references, to which the translator has added nine more, refers to work cited in the book, and this part of the bibliography is valuable. Two other brief sections of it, however, refer to general works and to special periodicals. Both refer chiefly to parasitology, and neither gives an adequate idea of modern parasitological literature. Of the nine general works cited, seven refer to parasites and, with one exception, they were all published in or before 1936. Of the meagre list of special periodicals, eight of the nine given deal with parasites, and many important parasitological journals are omitted. No one would expect a book of this kind to give a comprehensive list of works on parasitology, but, if any list at all is given, the reader is entitled to a modern and representative one.

The book is not, however, injured by this bibliographical fault. Its distinctive merit is its comparative study of parasitism, commensalism and symbiosis, and all students of these modes of life will read it with pleasure and profit.

G. Lapage

TEMPORARY REVERSAL ON BIFROST

The Bridge of Life

From Reality to Mystery. By Dr. Augusto Pi Suñer. Pp. vii+270. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1951.) 28*s.* 6*d.* net.

THE only bridge remotely resembling the one with which Dr. A. Pi Suñer is concerned, and like it mythical, is Bifrost. When last seen, the old Gods were moving steadily along it—out of the world and into Valhalla. This has led most men of science to assume that the process would continue and that the advance of knowledge would automatically restrict the area in which the gods could operate. We have preferred not to discuss whether Nature would ever be totally comprehensible, or indeed whether such a phrase can have any meaning, but have assumed that in our limited fields the gods were in retreat and materialist interpretations were extending.

This complacent attitude suffers jolts from time to time. There is a certain regularity in the process. As a new field of knowledge begins to be co-ordinated, some mystically minded pseudo-scientist thinks of a phenomenon in the middle distance and announces "You have explained so-and-so but you will never explain this". In this book the warnings are issued about instincts, consciousness and a curious mixture of life and time that obtrudes itself here and there. These are referred to as irreducible, and about them it is asserted that science cannot, and never will, tell us anything.

The best part of the book is a survey of various odd pieces of behaviour in animals and odd associations between them. This is interesting and lucid; but the choice of authorities is capricious. It is surprising to find Kipling's "Jungle Book" among them. The treatment of inheritance deals sympathetically with Lamarck and Lysenko; but on the basis of the rather dubious experimentation that held the stage in the 1930 period of this perennial wrangle rather than on the basis of more recent bacteriological evidence. There is some interesting backhanded Marxism in a section here in which the views of Cuvier and Linnæus are associated with their respective modes of acquiring titles. But much of this section is sketchy; it is a series of hints to the expert and confusions to the lay reader.

An examination of the borderland between two accepted and well-established disciplines—for example, between biology and chemistry—is always profitable if made by an expert, and even when it is made normally it is sometimes profitable. But an examination of all the borderlands at once needs more justification. *A priori* it is not likely that the same man could contribute usefully to each periphery. Experience with this book confirms the *a priori* judgment: not only does Dr. Pi Suñer meditate on most of the edges that exist, but he also considers some in which there seems to be little promise. There is, for example, a discussion about the biological significance of the probable use in the solar energy cycle of the biologically important elements hydrogen, carbon, nitrogen and oxygen.

It would be charitable to assume that some of the confusion is due to the translator, for the author has not been too well served by him. There are many infelicities of phrase and some scientific words are given wrong, or at any rate unusual, translations. But most of the fault lies with the author: he pays lip service to the scientific method and comments adversely on vitalism, metaphysics and "word-spinning"; but when the far side of his own medical speciality appears, we find as usual the ugly head of an ineluctible, irreducible god. Dr. Pi Suñer is not building a new bridge, he is simply repairing Bifrost and urging some of the gods to creep back. He may be successful in this, for irrationalism is now rife and books that encourage awe rather than curiosity spread it. We are given a medley of information and many quotations from the writings of the eminent; but the material is not arranged so as to bring out any clear principle. Instead, arbitrary assertions of inexplicability are made about some, at present unexplained, phenomena, and even these are not put very clearly. Such lack of clarity suggests that we may get warning of the return of the gods; the rout will be led by Loki, whose speciality was confusion.

N. W. Pirie

METHANE AND COAL*

By Sir ALFRED EGERTON, F.R.S.

COAL is the main stored source of the energy supplies of the world; every twenty years the world burns a volume of coal equivalent to the volume of Snowdon (a cone of base 8 km. by 1·1 km.). Coals were formed from ancient forests, mainly in the carboniferous era, about 250 million years ago, and the era lasted 30 million years or so. Some of the sources of coal are of later origin, and some is no doubt being formed now from decaying forests and swamps. Coals of all ranks—high and low rank—have a common generic relationship, as shown by the well-known curve of properties, such as the percentages of oxygen and of carbon falling within a fairly narrow band. In the main, coals are derived from the lignins and celluloses of plant debris and still retain some of the original structure of their vegetable origin. They are different chiefly because of the different pressure and temperature to which the material has been exposed; the higher-rank coals, in general, have been subject to higher tectonic pressure.

The Coal Survey has been providing a valuable examination of the coal deposits in Great Britain. Although there have been tremendous upheavals, displacements and folding of strata, the higher-rank coals have their origin in the central regions of the several coal-fields, and the coals of descending rank towards the periphery of the whole area or basin, in which coalification has occurred. Some ascribe this entirely to the effect of the pressure of the overburden, but, from investigations of German coal deposits, it appears that a fairly steep temperature-gradient may also be an important factor. Rock folding is consequent on great depths of sedimentary material, and high tectonic pressures and temperatures and disturbance of the seams result. There has also been modification by igneous intrusion in various regions.

It is dangerous to generalize on these matters; but it seems that study of the further coalification of low-rank material by submitting it to high pressure at various temperatures, carrying forward the work of Berl, Petraschek, Bode and others, might give further information on what has occurred in past ages. The constitution of coals has been tackled mainly from the other direction—analytically, by looking at their structure or treating them with reagents. These methods, along with X-ray studies, seem to show that, in the bituminous range, coal has a structure of interleaved or randomly oriented layer planes of hexagonally arranged carbon atoms within which lies a still more jumbled, more complex structure with oxygen, sulphur and nitrogen atoms forming some of the links between the ordered carbon structure. These structures seem to provide sub-units of particles ten times larger (about 3×10^{-6} cm. diameter). This picture of coal, composed largely of colloidal particles, as suggested by the late Dr. Bangham of the British Coal Utilisation Research Association, with a very fine pore structure between the particles, fits reasonably with the pore size deduced from the density and from the measured internal accessible surface-area (about 100 sq. m./gm.) obtained both by heat of wetting with liquid methyl alcohol and by adsorption at 25° C. of the vapours of methyl alcohol, *n*-hexane, etc. The internal surface measured by adsorption of nitrogen at low temperatures (about − 200° C.) has given values about twenty times smaller, indicating that the pores are of larger average diameter and implying that the coals should be more porous to gases than they are found to be. The discrepancy between these two methods of measuring the internal surface is one of the most interesting results of recent research at the laboratories of the British Coal Utilisation Research Association and in South Africa and elsewhere, for with the clearing up of a discrepancy new knowledge is always obtained. (The porosity of coals depends, of course, on the nature of the coal and is not directly related to rank; there is in general a minimum for coals of about 89 per cent carbon.)

Dr. Ivon Graham has shown that a certain dried coal dust can absorb about twenty times its own volume of methane at 10 atmospheres; but he also showed that methane absorbed under pressure in a small block of coal is locked inside and can only leak out through the fine pores very slowly; with anthracites, even when finely crushed, the gas leaks out quite slowly from the fine particles. Graham endeavoured to measure the pressure of the methane locked in the pores of the samples of coal taken from the coal face, and the highest figure he got was a little more than 7 atmospheres. Lindsay Wood (1880) obtained the highest figure recorded (34 atmospheres) for the Bensham seam at 1,270 ft. At 1,000 ft. depth, however, earth pressures would still be about twice as great. Graham's measurements of the amount of gas liberated when small lumps of coal are finely crushed showed that 200–600 c.c. are released per 100 gm. for different samples, depending on the type of the coal. On the average, it would not be more than about ten times the volume of the coal—considerably less than 1 per cent by weight. This work tells something about the origin of firedamp. Some of it is gas from the pores of the coal when it is crushed in the process of mining, but probably the greater part is methane which has got locked up under pressure during the formation of the coal in breaks in the underground coal and rock structure, and is released when the coal is disturbed. Work has been done by Russian workers with the view of ascertaining how much methane could be stored in the coal substance at the high earth pressures at which coalification processes take place.

Where does the methane come from? The peat-forming stages of decay of vegetable debris involve aerobic disintegration by action of micro-organisms and fungi. The biochemical process may cease with only partial decomposition of the woody substances or may proceed to more complete digestion of the plant material, providing a jellified mass. The process sooner or later smothers itself and becomes anaerobic, and the product becomes consolidated and

* Based on the first Coal Science Lecture of the British Coal Utilisation Research Association, delivered on May 7 at the Royal Society.

dehydrated under its own burden. Gases such as methane and carbon dioxide can still escape; but before long they may become imprisoned by the overlying strata. From this stage down, biochemical reactions diminish; but the product is gradually further dehydrated, devolatilized and compacted, in fact coalified and matured under increasing pressure and temperature. (It is rash to mention a temperature; it is probably generally somewhere between 100° and 150° C. and only in exceptional circumstances rises higher than 200° C.) The degradation of the original plant celluloses and lignins in the production of bituminous coal would involve the removal of nearly twice the mass as gaseous products (methane and carbon dioxide) and water, and some have supposed that a quarter of the mass of the coal would have appeared as methane. The late Prof. Briggs and Prof. Hickling have written most interestingly on the subject. In the production of bituminous coal some suppose that dehydroxylation occurs and carbon dioxide and water are eliminated, but others are puzzled that methane as well as carbon dioxide is found. The anthracitization of bituminous coals, however, certainly seems to require the production of about 10 per cent of the mass of the coal as methane, as the carbon/hydrogen ratio has to increase and there is not enough oxygen to account for removal of hydrogen by water alone. Nevertheless, the amount of methane found associated with coal in mines is on the average only about 1 per cent of the mass of the coal.

What becomes of the rest of it? Leaving this rather intriguing question, to consider the occurrence of methane in the coal measures again. The pressure of the methane in the pores of the coal, supposing it were the only gas formed in the later stages of coalification at high pressure, would be at the pressure corresponding to the depth of the seam. There is, in fact, a tendency for higher gas emission in seams of high-rank coals and at greater depths. Dr. Ivon Graham's experiments showed, however, that the pressure of the methane in the coal is very much lower than corresponds to its depth, and very different in different coals; this is no doubt partly due to difficulties connected with getting true samples of the coal, but it is presumably mainly due to the gradual diffusion and escape of part of the gas. Furthermore, the coal is often removed (by geological displacement) to regions at much lower pressure than the depth at which it was formed. In some places where there are porous deposits above the coal, the gas can gradually diffuse out of the coal and soak away; in other places where this occurs, the gas collects in a porous region which is sealed by impervious rock and, if then a boring is made into this porous region or into faulting, the methane which has collected will be released under its own pressure. There are apparently not many coal areas in Britain where this occurs. The well-known Point of Ayr Colliery in Flintshire yields free gas (250–650 cu. ft./min., 98 per cent methane) at considerable pressure (up to 20 atmospheres); there are other 'blowers' in Staffordshire and elsewhere.

The many disasters from firedamp explosions in mines and the measurements of the limits of inflammability eventually led to legislation to keep ventilation of the mines well below the limiting concentration for danger. (Men are withdrawn if the concentration exceeds 2·5 per cent and electric current is cut off at 1·5 per cent.) On the average, about 6 tons of air is pumped through the galleries for every ton of coal mined and the methane in the out-going air is seldom as high as 1 per cent. If the average were even as low as 0·25 per cent, the recovery of the energy in the methane which is at present wasted would be equivalent to 3 or 4 million tons of coal a year, and it is well worth an effort to save as much of it as possible. There are two main possibilities, either to drain off the methane before it gets into the ventilation air, or to utilize the energy of the methane in the ventilation air, without trying to separate it. The first of these two possibilities has recently come into prominence.

Drainage of Methane at Coal Mines

As this 'drainage method' has been described fully in several recent reports and papers, only brief reference is necessary. In the Ruhr, the Saar and in Belgium, methane is now being drawn off by a system of bore-holes in suitable places. Several systems have been developed, the cross-measure hole method being most in favour. This method is being applied in about twelve British pits. The amount of methane drawn off appears to depend on the movement of the coal caused by the mining operations; disturbance of the coal causes disturbance elsewhere, increased permeability of the coal seam and flow of the methane along bedding planes to regions of lower pressure, and subsequent release into the galleries, unless caught on the way. The percentage of methane which is piped off from the boreholes is generally fairly high, up to 90 per cent of that which would otherwise find its way out. A drop of 50 per cent or better in the methane content of the ventilation air can therefore result. The old-established drainage system at the Point of Ayr Colliery is in a different category, for there the gas is stored at high pressures in faults, and it is essential to give it vent before working the coal. In Belgium, the mines are linked by pipelines, and a supply of $3\frac{1}{2}$ million cu. ft. per day is maintained and is converted by cracking to a sulphur-free towns gas. In Germany, the gas is being compressed and used for motor transport. The object in view is increased safety in the mines, while obtaining a valuable product as a raw material for providing energy (power for the mines, or for heating of coke ovens, or as a raw product for other chemicals, synthesis gas, acetylene, etc.). Whether 'drainage' is worth while is very much a question of economics, setting the outgoings against the incomings, and each scheme has to be considered on its merits and in relation to local circumstances. According to report, it has been found that the value of the gas drained has generally more than paid for the installation and operating costs.

Utilization of the Energy of Firedamp in Ventilation Air

The main subject of this article is concerned with the second of the possibilities, namely, the direct utilization of the energy of the methane in the ventilation air. Dr. Roxbee Cox, chief scientist at the Ministry of Fuel and Power, has described in an admirable Hawksley Lecture to the Institution of Mechanical Engineers last year the projects which are in hand for the development of gas turbines for industrial purposes. One of the projects is one which has been suggested by C. H. Secord, of the Ministry:

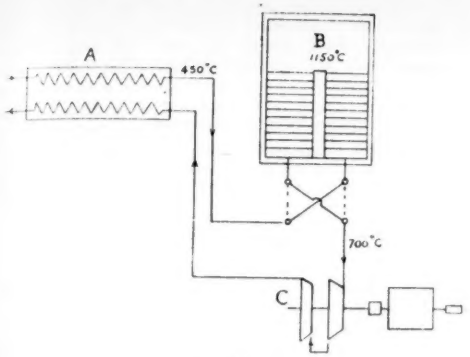

Fig. 1

if the waste methane in the ventilating upcast air from the coal mines could be burnt, the energy released could be converted by a gas turbine into sufficient useful work to provide a large part of the power needed in the collieries. Can such a small proportion of methane (about 0·5 per cent) be burnt? Knowing that methane can be oxidized well below the limiting mixture strength needed for flame, the suggestion seemed to me worth pursuing, and a few preliminary experiments were made (early in 1949) which showed that fairly rapid combustion could be got in the region of 700–900° C. R. G. Voysey, a member of Dr. Roxbee Cox's staff, thereupon produced a scheme, and Fig. 1 shows the general principle: *A* is a preheater exchanging heat between ingoing and outgoing gases, *B* is a regenerator-exchanger or 'booster', in which the gases are maintained at the temperature necessary for reaction, and *C* is the turbine.

If the temperature rise caused by the combustion of about 1 per cent of methane is 250° C., and 900° C. is the temperature to which it has to be raised for rapid ignition, then, supposing that it enters at 450° C., it will have to pick up 450° C. from the booster, the temperature will rise to 1,150° C. on ignition, and after giving up heat to the other leg of the booster it will drop 450° C. and go to the turbine at 700° C. The valves of the booster are changed over at appropriate intervals to keep the process going. It is very necessary that the combustion should be rapid, otherwise the exchanger booster will be large and costly.

The booster, largely designed by P. D. Edmundson, of the Ministry of Fuel and Power, and constructed by the Incandescent Heat Co., has already undergone successful trials. The engineers, in designing the booster, needed to know how the methane would burn in it. The velocity of the air stream would be about 200 ft./sec. (65 m./sec.), and the residence time in the hot zone might therefore be only a few milliseconds. At what temperature would the combustion start in such circumstances? Would it be completed quickly when started? Could it be burnt at a lower temperature by addition of special vapours or by change of surface conditions? How would the combustion be influenced by other combustibles? These were some of the questions investigated by A. D. Meads and later by H. Hirsch, under Dr. J. H. Burgoyne's supervision, in the laboratory of the Department of Chemical Engineering and Applied Chemistry of the Imperial College of Science and Technology, London.

Investigation of the Combustion of Weak Mixtures of Methane and Air

It was decided to fix on a rate of flow (0·126 cu. ft./min. at 20° C.) and size of refractory tube ('Mullite' 3/16 in. internal diameter) which would correspond approximately with the expected flow-rates and surface/volume ratio assumed for the preliminary design of the booster matrix. The effect of change of composition and of pressure on the temperature for rapid combustion and on the duration of the reaction was studied. The methane and air could either be preheated separately or after mixing. It was established in the preliminary work that the reaction was taking place homogeneously in the gas phase, starting not at the surface but between the boundary layer and the fast-moving core, and that the mixing of the two separate streams was very rapid and occurred well within 1 cm. of admission (0·4 m.sec.). Most of the work thereafter has been done by heating the methane and air separately, and bringing them directly into the reaction space.

The 'Mullite' tube was about 1 m. long; the length of the reaction space (less than 10 cm.) could be changed by pushing in the closely fitting exit tube. The furnace was specially contrived to provide even heating, and the temperatures were measured by a suction pyrometer in an identical tube alongside, through which passed the same flow of air without methane. The changes of percentage of methane and of carbon monoxide have been measured by infra-red analysers, which have made it possible to study these fast reactions. The following figures show the temperatures which are needed to cause 95 per cent combustion of a 1 per cent methane/air mixture:

Length of reaction space	Residence time at inlet after mixing	Temperature of gases at inlet
6·5 cm.	3·8 m.sec.	1,020° C.
4·5	2·4	1,041
1·5	0·3	1,076

All the temperatures referred to are the temperatures of the preheated gases entering the reaction space (and therefore no correction is needed for rise in temperature due to reaction). In 4·5 cm. only 10 per cent is burnt at 1,020° C., so that in the next 2 cm. the combustion, when once started, is all over in about 1 m.sec. There is a delay of nearly 2½ m.sec. before any appreciable reaction happens. This is fundamentally interesting, in relation to some other experiments on flame propagation. In a flame, gases are heated to the temperature at which they inflame. In these experiments they are preheated until they react rapidly, and that is just what is happening in a flame front.

If gases are passed through a burner in which the gas stream is divided into a number of small channels, in each of which there is stream-line flow on emergence, the streams have a velocity distribution which is the same across the burner. One gets a flat flame[1]. In order to maintain the flame, the gases must be heated up to the temperature of inflammation (that is, the temperature of the lower boundary of the surface of the flame), which for a weak methane/air mixture is about 1,200° C. The distance in which the heating can occur is about 0·03 cm., because at that distance from the flame-front the gases are still too cold to react rapidly. They are moving at about 6 cm./sec. (at 20° C.), so they have less than 2 m.sec. in which to react and reach a temperature of 1,200° C. If when they are already at 1,000° C. according to the 'Mullite' tube experiments, they seem to need 2–3 m.sec. to ignite, it scarcely seems likely that the time

available in the flat flame would be sufficient to inflame the gas at the flame boundary. In making that statement, it is assumed that the gases depend for their ignition on heat generated by pre-reactions set up by heat conducted from the flame. It is therefore believed that something else is happening in the gases before they reach the flame front. It is thought these experiments support the view that radicals (probably hydrogen atoms) streaming back from the flame, besides the heat of the flame, are necessary to start the reactions and maintain a flame in existence. Experiments carried out by B. C. Mullins at the laboratories of the National Gas Turbine Establishment on ignition of methane in fast streams of gas indicate even longer ignition-delays at 1,000° C. than those obtained at the Imperial College. I have mentioned this offshoot of the work because it illustrates how study of a technical problem can lead to results of importance in purely academic studies, in this case on the problem: How does a flame maintain itself?

To return to the oxidation of methane, it has been found at the Imperial College that: (1) the effect of pressure up to 2½ atmospheres only slightly decreases the temperature of combustion; but oxygen enrichment decreases it quite considerably; (2) the weaker the mixture (down to 0·5 per cent), the lower the temperature for rapid combustion; methane therefore appears to inhibit its own ignition at these high temperatures; (3) that 0·125 per cent of hydrocarbons and hydrogen lower the ignition temperature quite appreciably but only in proportion to their contribution to the total heat content of the mixture in burning to carbon monoxide.

Does the methane burn at once completely? It was important to know the answer to this question, for, if it is only partly burnt, the full available energy cannot be converted in the turbine. With constant residence time (4–5 m.sec.), the 1 per cent methane burns more and more completely as the temperature rises, until at 1,020° C. it has been completely burnt. Carbon monoxide is formed by the combustion of the methane; its combustion is inhibited by the methane, and it only begins to burn after practically all the methane is burnt. The carbon monoxide, however, does not burn completely in the time available unless the temperature is raised to 1,050° C. These results show that the combustion of methane is not a single but a dual process, being composed of two separate processes of different rate: the combustion to carbon monoxide; and the subsequent combustion of the carbon monoxide, the second being inhibited by the first. Fig. 2 shows how marked is this effect. 1 per cent of carbon monoxide (moist) would burn rapidly at 777° C., but with 1 per cent methane it will not burn until the temperature is raised a further 200°, and then only when the methane has been burnt. It is obvious there is some radical essential to the combustion of carbon monoxide which is destroyed by a hydrocarbon, like methane.

This effect has been noted by others in mixtures of much higher concentration in the region of ignition limits at lower temperatures. During the Second World War, the flaming of exhaust from aircraft at night had to be reduced. It was found that hydrocarbons (lubricating oil, for example) injected into the exhaust helped to prevent the blue glow due to combustion of residual carbon monoxide when the hot exhaust-gas discharges into the air. R. R. Baldwin[2] has shown that the combustion of hydrogen, as well as carbon monoxide (moist), is inhibited by

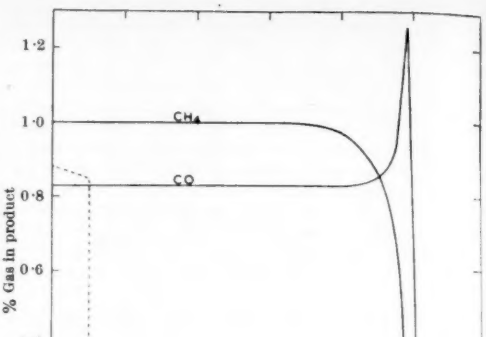

Fig. 2

hydrocarbons to an extent dependent on the oxygen concentration. He has suggested that the hydrocarbon removes hydrogen atoms, since these alone react with oxygen in the hydrogen–oxygen reaction. He assumes that these hydrogen atoms react with hydrocarbon and give rise to a hydrocarbon radical, which is afterwards destroyed. This explanation, however, does not seem to fit with the self-inhibition of the oxidation of methane.

It is not at all certain yet what is precisely happening in any kinetic gas reaction; even in the case of hydrogen and oxygen, new phenomena turn up which have to be accounted for by new suppositions. D. R. Warren has suggested that ozone is the only likely common constituent of all oxidation reactions, and yet his own discovery of the effect of boric acid on the second ignition limit of hydrogen–oxygen seems to rule out at once any explanation of the hydrogen–oxygen reaction in terms of ozone as a chain carrier. Nevertheless, the dry carbon monoxide reaction seems to demand ozone as a chain carrier, and it is interesting that in these methane weak-mixture reactions ozone is certainly formed at an early stage. These experiments on the oxidation of weak mixtures of methane have yet to yield their full fruit. In this connexion, G. J. Minkoff and A. J. Everett have found that, in spark-ignited mixtures of methane and oxygen cooled in liquid air at low pressures, the flame is remarkably rapid and is attended by a glow lasting several milliseconds, and that considerable amounts of ozone and hydrogen peroxide are chilled out on to the walls of the tube; methyl hydrogen peroxide is also detected, but no formaldehyde. These various lines of work are converging to provide quite considerable information about these rapid chain reactions which control the propagation of flames.

There are now two ways open for the utilization of the mines gas—either by drainage, or by the direct combustion of the methane in the ventilating air. Which is the better way will depend on local circumstances and many other different considerations. They are not mutually incompatible. The drainage method only removes part of the methane that would

otherwise find its way into the ventilating air. If, for safety reasons, methane drainage were necessary, it might still be thought worth while, instead of burning the methane under boilers or in diesel engines, to burn it in a combustion chamber along with the ventilating air containing the rest of the methane and gain the power by gas turbine. But having separated methane at high percentage, it seems a pity to burn it; it should be used so as to obtain its value as a high-grade fuel.

Methane as a Fuel for Internal-Combustion Engines

Methane is an excellent fuel for spark-ignition engines. M. Pearce had shown that the same engine on methane with spark ignition at 14 : 1 compression ratio gave 34 per cent more power than when running as a diesel engine on oil. This is because of the high knock-rating (highest useful compression ratio 16 : 1) of methane. N. P. W. Moore and W. T. Lyn have been studying the behaviour of methane in a motor engine at high pressure and have shown that a pale-blue flame precedes at a somewhat lower pressure the white flame of the true ignition. Again, this is perhaps evidence of the dual nature of the combustion.

Attention is directed to the behaviour of methane in engines not only because of its special interest in relation to the problems of combustion, not only to show again how all these different aspects of the combustion of methane interconnect, but also to suggest that its special value as a fuel for internal-combustion engines should not be neglected. Methane obtained by the drainage method in the Ruhr district is being compressed and utilized for motor transport, and this may well be one of the most profitable ways of using it, rather than using it for heating coke ovens or passing it into gas mains after suitable reforming.

Liquid Methane

For many years we have been interested in the possibilities of methane in the liquid state (b.p. − 161° C.). The late Lord Cadman directed my attention to the enormous volumes of methane which went to waste in the Persian oil-fields. I suggested at the time that it might be liquified and shipped as liquid, and transported like liquid oxygen. This half-crazy idea developed into a less crazy scheme to store gas for domestic use as methane; the storage capacity for the liquid for the same thermal energy would be about a thousand times less than that for the gas. Another idea, that it might be used as a liquid for motor transport, was fully investigated in the Imperial College during the Second World War; and it was shown to be a possible substitute for petrol. The carbon content of coal could be more easily converted to methane than to oil, so that possible supplies of a fuel alternative to petrol were great. Omnibuses were run for about 25,000 miles in the public service on liquid methane in special vacuum-jacketed tanks, which were developed for the purpose. When petrol became available again, the interest flagged; but it is possible that it might revive with methane drainage, or possibly when a store of gas is required to meet special loads. The section at the Imperial College for research on low-temperature technology arose out of our interest in these technical problems relating to the use of methane.

[1] Egerton and Thabet, *Proc. Roy. Soc.*, A, **211**, 445 (1952).
[2] Baldwin, R. R., Corney, N. S., and Precious, R. M., *Nature*, **169**, 201 (1952); cf. also Naylor and Wheeler, *J. Chem. Soc.*, 2456 (1931).

BIRD CONSERVATION IN EUROPE

THE Fifth Conference of the European Continental Section of the International Committee for Bird Preservation was held in Bologna, Italy, during May 14–16 under the chairmanship of Dr. Boje Benzon (Denmark). The meeting was attended by delegates of the national sections for Austria, Denmark, France, Germany, Great Britain, Italy, the Netherlands and Switzerland, together with representatives of the International Union of Biological Sciences, the International Union for the Protection of Nature and the Conseil International de la Chasse.

One of the most urgent questions discussed was oil pollution of the sea and consequent destruction of sea-birds. A preliminary survey made by the Royal Society for the Protection of Birds in conjunction with the British Section of the International Committee for Bird Preservation during the winter and spring 1951–52 as to the numbers and species destroyed in this way around the coasts of Great Britain showed 70 per cent of the birds found on the beaches were gulls and 16 per cent guillemots and razorbills. A similar survey carried out in Holland produced a different proportion of birds destroyed, 45–50 per cent being guillemots and only a few gulls. The percentages of other species affected also varied in the two countries. On the coasts of Denmark, scoters and eider ducks appear to be the most frequent victims.

A valuable report on the work being done in the analysis of deposits of oil waste to endeavour to trace the type of ship from which oil pollution has emanated was contributed by the British Section. Work carried out so far shows that specimens of oil deposits taken from beaches were wholly of petroleum origin and identifiable as two kinds of oil, waxy sludge or bottoms as deposited in the tanks of tanker vessels carrying crude oil, and heavy fuel oil. The analysis of oil obtained from the feathers of birds, on the other hand, proved to be fuel oil only. The presence of the latter oil in the sea probably follows the pumping by ships of bilges and ballast tanks, and as this oil remains as a viscous film when spread on water it is more likely to cause oiling of birds. The urgent necessity for such research as a means of assisting to solve the problem of prevention of oil pollution of the seas was appreciated by the representatives of all countries present. A resolution was passed directing attention to investigations in progress into the nature and sources of the types of oil pollution and the need for further facts on important parts of the problem, pressing for completion of the investigations, and asking the governments concerned to give these the fullest support with the view of reaching a constructive and acceptable solution to this serious trouble.

The protection of migratory birds is a question of prime importance to the countries of Europe, particularly with regard to those species which are considered as sporting birds and as suitable for food. Reports on migratory birds giving lists of those regarded as sporting birds, the close-times accorded to both sporting and other migratory birds and details of any species which have decreased, with suggestions as to the reasons, were furnished by the national sections of France, Germany, Great Britain, Greece, Italy and the Netherlands. The interpretation of the term 'sporting birds' varies considerably in

different parts of the Continent, thrushes being considered fair game in a number of countries, and in some all small passerine birds are regarded as suitable for the pot. In Germany and Italy, a decrease of all waders and water-birds is reported, and a similar situation is apparent in parts of France, whereas in Greece there is a serious decrease in all sporting migratory birds. Whether other migratory birds are decreasing or not is more difficult to observe, and some countries had no information on this point; in Italy, however, a decrease in swallows and swifts is attributed to the ever-increasing use of insecticides. The need for the further protection of migratory birds was evidenced by the passing of resolutions pressing that shooting in spring should be everywhere prohibited, whether on coasts or inland, and that all methods of capturing birds *en masse* (nets, snares, bird-lime, etc.) should be forbidden.

The proposal put forward at the Conference held in Uppsala in 1950 that an endeavour should be made to establish a series of bird reserves on the main migration routes in Europe was also reported upon. The Camargue Nature Reserve, in the Rhône delta, which was created, and is administered by, the Société d'Acclimatation de France and where protection is afforded to many migratory birds on passage to other European countries, was specially discussed. Grave concern was expressed over the possible effects upon bird-life of a further extension of economic exploitation of the area. A resolution was passed in which it was stated that the Conference considered that the unique and irreplaceable scientific significance of the Camargue as a nature reserve of first-rate European importance ought to be officially recognized by agreement between the interested governments, and requested the French Government to accept the principle that large parts of the Camargue should be permanently safeguarded not only for future generations of scientific workers and friends of Nature, but also for the conservation of the stock of migratory birds on their way to other European countries. The Conference also invited the Société d'Acclimatation de France to accept the help of other countries.

Birds which are a menace to other species present a difficult conservation problem, and the situation with regard to the herring gull in the countries bordering the North Sea was the subject of reports from Denmark, Germany and the Netherlands. A survey made of the herring gull colonies in the three countries showed a total of 56 colonies, of which 31 consisted of more than 1,000 pairs, 12 from 100 to 1,000 pairs and 13 less than 100 pairs. Various lines of investigation are being pursued, such as ringing, study of food taken by the birds and the effect they have on other species nesting in the proximity of colonies. Results of measures taken to control the numbers of gulls were also reported upon. In Holland, herring gulls prove a menace to other species and the control of their numbers is considered essential; in Denmark, on the other hand, they are found to cause little damage to other species and are considered a necessary part of the ecology of sea-bird colonies. Ringing results have established that German herring gulls are non-migratory and, though not yet complete, the Dutch results indicate that in the Netherlands the birds do not wander far from their original nesting grounds.

The International Convention for the Protection of Birds which was signed *ad referendum* at a Government Conference in Paris in 1950 has made no further progress, the majority of national sections present reporting that their respective governments were awaiting the passage of national legislation before adhering to the Convention, though some signified that their governments would not long delay.

The investigations into the status of the Anatidæ being carried on in various countries were reported upon, and Dr. Edward Hindle, honorary director, presented a report on the work of the International Wildfowl Research Institute which was set up in London to correlate these investigations and act as a centre of information.

Other subjects dealt with were the conditions of birds transported alive from tropical countries to Europe, the use of birds' feathers in millinery and excessive shooting and netting of birds in parts of France.

CENTENARY OF THE AMERICAN GEOGRAPHICAL SOCIETY

THE American Geographical Society of New York, the oldest society of its kind in the United States, has now reached a ripe age for an American institution —one hundred years. It ushered in its centennial year with a largely attended dinner last autumn, and on May 22, 1952, it celebrated its 'Charter Day' with a convocation at which Mr. John Foster Dulles spoke and an exhibition was formally opened. The approaching centennial was a factor leading to the choice of the United States as the meeting-place for the Seventeenth International Geographical Congress, which is to be held in Washington in August. At special ceremonies the Society will entertain and honour foreign geographers on their arrival in New York *en route* to the Congress.

The Society is twenty-one years younger than the Royal Geographical Society and has had a somewhat comparable career*. Its founders consisted of merchants, ship-owners, and other business and professional men—among them, an influential group of newspaper publishers, editors, historians and writers. Until 1871 the institution was called "The American Geographical and Statistical Society", and about a third of the papers read before it at that time had to do with statistics. From the beginning the Society has kept up a consistent interest in exploration, though to a lesser degree than its sister Society in London. It aided the American Arctic expeditions of Kane, Hayes, Hall, Greely, Schwatka, and De Long, during the 'fifties, 'sixties and 'seventies, and later was closely associated with Peary (who served as president during 1903–6), Stefansson, Rasmussen, Wilkins, Byrd, Louise A. Boyd, Ronne, and many other explorers. Judge Charles P. Daly was president from 1864 until his death in 1899 and did more than anyone else during its first half-century to establish the Society on firm foundations. In 1874 he said that one purpose of geographical societies was "to press the importance of scientific attainment . . . upon all who are ready to encounter the toil, the privation, and the peril that are incident to such noble under-

* For further details on the history of the Society see the following recent publications by Dr. J. K. Wright, director during 1938–49 of the Society: "Geography in the Making: The American Geographical Society, 1851–1951" (New York, published by the Society, 1952), reviewed on p. 89 of this issue of *Nature*; "The American Geographical Society: 1852–1952", *The Scientific Monthly*, **75**, No. 3, 121 (March, 1952); "British Geography and the American Geographical Society, 1851–1951", *Geographical Journal*, **118**, 153 (1952).

takings [that is, exploring expeditions], that they may bring back what will be honourable to themselves and useful to the world". The Royal Geographical Society and the American Geographical Society have adhered to this principle.

Both Societies have also striven to advance geographical education along modern lines in their own countries. In the mid-'eighties the Royal Geographical Society took the lead in the movement that established geography in British universities and effected its improvement in the schools. Similarly, in the mid-'nineties the American Geographical Society adopted a policy of close collaboration with teachers. It gave moral encouragement and material assistance to the Association of American Geographers during the latter's formative period. The Association, consisting largely of university geographers, was founded by Prof. W. M. Davis in 1904 for the development of geographical research. The American Geographical Society also came to the rescue of the school teachers' *Journal of Geography* when that estimable little magazine was about to expire in 1918. In 1912 the Society conducted an excursion through the United States to the Pacific coast and back. Ninety American and forty-three European geographers participated, the Europeans as guests of the Society through the generosity of Mr. Archer M. Huntington, the Society's outstanding benefactor. This extraordinary trip forged new bonds of friendship, esteem and collaboration across the Atlantic—bonds that held firm despite the First World War and that help to explain a broadening of the Society's world outlook in the years that followed.

Isaiah Bowman (1878–1950) was the first director; he served from 1915 until 1935, when he resigned to assume the presidency of the Johns Hopkins University. Before his appointment, the Society had confined its activities almost entirely to publishing a journal, building up an excellent library, holding semi-popular lectures, and awarding medals and other honours. Dr. Bowman more than quadrupled the membership and raised the scientific standards of the journal, which was renamed *The Geographical Review* in 1916. He inaugurated several series of monographic publications, including the well-known Research Series and the Special Publications, in which some eighty works have appeared to date. Furthermore, during Dr. Bowman's administration, chiefly through his initiative, and with the financial support of Messrs. Huntington, J. B. Ford and others, the Society embarked upon a new type of enterprise: the conduct of large programmes of original investigation both by members of its staff, who were added for the purpose, and by outsiders under the Society's general supervision. These have dealt especially with techniques of exploration and cartography, and with the geography of Latin America, of the polar regions, and of pioneer settlements in different parts of the world. They have yielded fruit in new instruments and techniques of reconnaissance surveying and map-making, in a great "Map of Hispanic America on the Scale of 1 : 1,000,000" (107 sheets), and in many other maps, monographic works, and periodical articles. In these ways the Society extended its influence and gained recognition as a genuine research institution.

The American Geographical Society is now crossing the threshold of its second century under the invigorating leadership of a British geographer. In 1950 Dr. George H. T. Kimble, formerly of the University of Reading, and later professor of geography in McGill University, Montreal, was appointed director. He is putting into effect a reformulation, recently adopted by the Council, of the Society's time-tested policies. Research is to be maintained and accelerated. The Hispanic-American programme will continue, though on a reduced scale. Fresh fields are being energetically opened: the geography of diseases, the study of glaciers in relation to climatic changes, and investigations of the distribution and use of natural resources. The Society is also seeking new ways and means whereby geography may be applied to useful purposes and is striving to "bridge the gap between geographical scholarship and teaching", a gap that yawns altogether too wide for safety, not only in the United States but also in most of the other countries of the world.

OBITUARIES

Prof. H. A. Kramers

An untimely death has removed from the world of physical science one of its most original and inspiring figures. Prof. H. A. Kramers was professor of theoretical physics in the Technical University of Delft.

Prof. Kramers was universally respected as a master in many fields, skilful alike in putting to use the most subtle methods of algebra and in bringing to light the essential physical features of the most varied phenomena. He was universally liked as a man: everyone who came into touch with his warm and fine personality yielded to its charm and mingled respect with affection. His shrewd judgment of human affairs and his interest in people made him eminently suitable for the responsible positions he occupied in international bodies ministering to the common needs of physicists of all nations. Deeply concerned with ethical problems, he regarded the control of nuclear energy as a most compelling task. His work in the Atomic Energy Commission of the United Nations Organization was a sacrifice accepted in all simplicity: he came back with his health irreparably undermined. Although in his last years his curiosity and enthusiasm for the new advances of physics were as youthful as ever, he had not recovered the vigour of his former days. Yet he strained to the last his failing strength in the fulfilment of his unselfish work for science.

To the physicists of my generation, who knew of the heroic days of quantum theory only by the tradition received from our elders, Kramers had about him the glamour and the wisdom of the pioneer. His early association with Bohr, his later collaboration with the young Heisenberg, exerted a marked influence on the shape taken by the development of quantum mechanics. He had been brought up against the background of the Lorentzian tradition, still very much alive even to this day in Holland, and the incisively critical spirit of his teacher Ehrenfest could not have failed to leave its mark on him. Kramers's role in this first period of his scientific life has thus been to carry over, in a highly original form, the great classical traditions of Dutch physics into the growing tide of quantum theory. This he did, above all, by his masterly analysis, in the spirit of Bohr's correspondence argument, of those optical problems which had absorbed Lorentz's attention so fully. His very first attempt, on the intensities in the Stark effect, became at once a model for the methods of

quantum theory in its initial stage; so much so that when Schrödinger first wanted to test the powers of his wave-mechanics, he quite naturally took up that very problem for comparison. But a still more decisive advance was Kramers's reformulation of the theory of optical dispersion, which paved the way to Heisenberg's great discovery.

After his return to Holland, the task he accomplished, though of a different character from his work in Bohr's circle, was no less honourable and no less exacting. If the old Dutch tradition of theoretical research in physics has been so brilliantly upheld and continued along the lines of quantum theory, it is due in no small part to the powerful influence of Kramers's personality. By his versatile activity he contributed much himself to the development of the methods of quantum mechanics and to their application to many fundamental problems of atomic physics. But who will tell how much he stimulated his fellow-workers by his example, his experimental colleagues by his advice, his pupils by his guidance, his students by his teaching? Besides all this, there was Kramers the man, to whom nothing human was foreign. His friends would never seek in vain his wise counsel in affairs of public import, or his warm sympathy in their private worries. His help often came unsought, and sometimes a hint, unobtrusively preferred, would make you realize that, unknown to you, he had given long and careful thought to your problems. His name will live in the annals of science; his gentle image in the hearts of his friends. L. Rosenfeld

Prof. Louis Guillaume

The death, following an accident at Strasbourg on May 29, is reported of Prof. Louis Guillaume, Ingénieur en chef at the Bureau de Recherches Géologiques et Géophysiques in Paris, and well known and respected among British geologists.

Guillaume, who was born in 1894, held academic posts at both Caen and Strasbourg, and in 1941 helped to found the Bureau des Recherches Géologiques et Géophysiques, the object of which was to co-ordinate, facilitate, and if need arose, to initiate, the search for useful economic materials in France. He was the author of numerous scientific articles in the fields of palæontology and stratigraphical geology, and his premature death deprives his colleagues of his collaboration in a number of important works, particularly on hydrogeology, for which he had assembled an extensive and valuable documentation.

Guillaume was a fervent anglophile and had made many friends in Great Britain; they will mourn the passing of a generous and dynamic personality.

A. C. Townsend

NEWS and VIEWS

Medical Protozoology in the University of London: Prof. H. E. Shortt, C.I.E., F.R.S.

Prof. H. E. Shortt, who has held the chair of medical protozoology in the University of London at the London School of Hygiene and Tropical Medicine since 1947, is to retire in October. Prof. Shortt was formerly in the Indian Medical Service, and has made discoveries of fundamental importance in the field of tropical medicine. During his work in India on the etiology of kala-azar, carried out over a period of twenty-five years, he proved that the transmitting agent was *Phlebotomus* and contributed profoundly to the knowledge of this disease and its causal organism. In recent years he has carried out brilliant researches on the life-cycle of the malaria parasites, in which Dr. P. C. C. Garnham collaborated, and for which they were jointly awarded in 1951 the Darling Medal and Prize given by the World Health Organization.

Dr. P. C. C. Garnham

Dr. P. C. C. Garnham, who is to succeed Prof. Shortt, was in the Colonial Medical Service during 1925–47 and was director of the Division of Insect-borne Diseases in Kenya during the last four years of his service. He has published numerous original articles, many of which are concerned with malariology, a subject in which he has specialized and achieved distinction. In Kenya he carried out important research not only on malaria but also on relapsing fever, plague, onchocerciasis and jungle yellow fever. The epidemiology of these diseases and the bionomics and control of their insect vectors were his special concern. An outstanding success in this field was his discovery of the use of DDT in destroying the larval stages of *Simulium neavei*, the vector of onchocerciasis in Kenya and other parts of East Africa. This method of control has resulted in the complete eradication of the insects in certain endemic foci. On joining the staff of the London School of Hygiene and Tropical Medicine as reader in medical parasitology in 1947, he participated in the experimental work which led to the first discovery of a pre-erythrocytic stage in the life-cycle of mammalian malaria parasites. His collaboration in this work and in the subsequent researches which established the presence of this long sought-for missing link in the life-cycle of the human malaria parasites, *Plasmodium vivax* and *P. falciparum*, has earned for Dr. Garnham an enduring name in the history of tropical medicine research.

Institution of Mining Engineers: President for 1953–54

Mr. J. Cecil Mitcheson has been elected president of the Institution of Mining Engineers for the year 1953–54, and will succeed Mr. R. J. Weeks at the annual general meeting to be held next January. Mr. Mitcheson comes of an old mining family, his great-grandfather having worked with George Stephenson at the Old Killingworth Colliery; both his grandfather and father were also associated with the industry. Mr. J. C. Mitcheson was educated at Bootham School, the Royal Military Academy, Woolwich, and the University of Birmingham, where he graduated B.Sc. in mining. After obtaining his colliery manager's certificate, he was appointed lecturer in coal mining and demonstrator in mine rescue in the University of Birmingham under the late Prof. K. Neville Moss. In 1924 he returned to the mining industry to assist his father in his consulting practice

in the Midlands, and was later appointed managing director of the Birch Coppice Collieries of Morris and Shaw, Ltd. During the Second World War he was group production director for the Warwickshire Coalfield. When the mines were nationalized, Mr. Mitcheson served for a time as mining development engineer to the West Midlands Division; later he resigned to take up consulting work and to look after the interests of his former company. He has visited mines in France, Germany, Belgium, Spain and the United States, and has recently reported on the brown-coal deposits of Iceland for the Icelandic Government.

Paris to London Television Relay

DURING the period July 8–14, a new and advanced experiment in the international exchange of television programmes was carried out between Paris and London. By co-operation between Radiodiffusion et Télévision Françaises and the British Broadcasting Corporation, a part of each day's programme in the public television service in Great Britain originated in Paris. Due to the failure to achieve uniformity in the television standards in use in Europe, it was necessary to convert the television signals from the French 819-line system to the British standard of 405 lines. This conversion was carried out at Cassel by equipment developed by the B.B.C. in which the picture with the original number of lines on the screen of a cathode-ray tube is re-scanned by a television camera operating on the number of lines normally used at the receiving end of the circuit. Earlier experimental work had shown that the success of this technique depended on the use in the picture tube of a screen having a phosphor with a decay time comparable with that necessary to scan a single frame of the television image. By this means the camera views an image that is virtually continuous during each frame. The phosphor used in the cathode-ray tube at Cassel is zinc beryllium silicate, which has an exponential decay characteristic such that the brightness of any particular point in the image falls to about 28 per cent of its original value during the time of scanning one frame. A Marconi Image-Orthicon camera was used to re-scan the picture at the 405-line standard. From Cassel the pictures were transmitted to London by a series of radio links. Apart from some intermittent technical faults with both the sound and vision signals, the experimental programmes could be regarded as very successful in indicating the possibilities of exchange of programmes between European capitals and other places separated by a few hundreds of miles. As a combined operation between R.T.F. and B.B.C., this achievement marks a new step forward in the development of outside television broadcasting.

The Chemical Society of the University of Edinburgh

FOR his presidential address to the Royal Society of Edinburgh delivered on July 7, Prof. James Kendall spoke on "The First Chemical Society, the First Chemical Journal, and the Chemical Revolution". He discussed the first volume of the proceedings of the Chemical Society of the University of Edinburgh, which was discovered a few years ago in the library of the Royal Irish Academy and has since been presented to its original owners in the University of Edinburgh (see *Nature*, **159**, 867; 1947). The volume is a well-bound folio of 452 pages in copper-plate manuscript, containing thirty-two dissertations on topics of chemical interest. Although the communications presented are not of major scientific importance, they do afford a unique record of contemporary chemical thought. In particular, they disclose one fact of significant historical interest, namely, that Joseph Black, commonly regarded as among the last to accept the 'chemical revolution' of Lavoisier, must have been among its earliest advocates, since the majority of his students were already converts to the oxygen theory of combustion in 1785–86. The penultimate paper, by Mr. John Carmichaell, merits special consideration. It consists of a violent attack upon the long-established doctrine of phlogiston, which Lavoisier overthrew, and concludes with a quotation from Virgil applicable thereto: Venit summa dies (Its last hour has arrived). That pronouncement was obviously endorsed by Mr. Carmichaell's colleagues, since on the title-page of his medical graduation thesis in 1787, where he continues the attack, he proudly announces himself as "Extraordinary Member and President for the Year of the Chemical Society of Edinburgh". This thesis was almost certainly one of two sent by Black to Lavoisier in 1790 as proof that Edinburgh students, while enjoying "the most perfect liberty of chuseing their philosophical opinions", had in general embraced his system. Incidentally, Mr. Carmichaell was one of the few original members of the Society who was a native Scot.

International Commission on Glass

THE International Commission on Glass held its annual meetings under the presidency of Prof. W. E. S. Turner throughout the week June 30–July 5. The first two days were spent in London, in part in the rooms of the Institute of Physics, and in part at the Research Laboratories of the General Electric Co., Ltd., Wembley; the meetings on the other four days were held in Sheffield at the Department of Glass Technology in the University. Representatives of Belgium, France, Germany, Great Britain, Holland, Japan, Spain, Sweden, Switzerland and the United States attended. The technical work of the Commission occupied three full days, one of them devoted to an open session; the two other days to committee work on a variety of subjects classified under the group headings of glass literature; chemical properties of glasses; physical properties of glasses; glass furnace problems. Reports were presented on tasks or projects previously undertaken by affiliated organizations; agreements were reached on a number of fundamental issues, and plans were prepared for further collaboration. The International Standards Organization sent, by invitation, two observers to the meetings. Among the events were visits to the Research Laboratories and the glass works of the General Electric Co., Ltd., and to the imposing new works—unique in Europe—at Harworth, near Doncaster, where the glass envelopes for electric lamps and radio valves are manufactured at tremendous speed. Prof. W. E. S. Turner, to whom illuminated addresses were presented from Germany and Japan, will, after being continuously in office for twenty years, retire from the presidency in 1953. He will be succeeded by Dr. B. P. Dudding, honorary secretary of the Institute of Physics and at present secretary of the Commission. M. Henri Vandecapelle, director of the Institut National du Verre, Charleroi, was appointed secretary-elect.

Problems of Land Reform in Under-developed Countries

In the under-developed regions of the world there are many impediments to the improvement of rural living standards. Among them are the fragmentation of holdings, the concentration of land ownership in a few hands, high rents and insecurity of tenure, low wages, exorbitant taxation and inadequate provision for agricultural credit. In a report, entitled "Land Reform: Defects in Agrarian Structure as Obstacles to Economic Development", published by the United Nations' Department of Economic Affairs (pp. 101. New York: United Nations. 75 cents. London: H.M.S.O., 1951. 5*s*.), it is emphasized that it is the agrarian structure and, in particular, systems of land tenure which prevent a rise in the standard of living of small farmers and agricultural labourers. Land reform, however, if it is to be effective, must comprise improvement in all the social and economic conditions affecting farm life. Changes in the land tenure systems are more likely to lead to a rise in the standard of living of the rural community when they form part of a general programme than when they are undertaken in isolation. The provision of credit facilities, co-operative marketing, technical advice and health services are among the major services needed. The report points out that if steps are not taken to provide facilities of these kinds to newly established small farmers, many of the benefits which might be expected to result from reform of the land tenure system will be nullified.

Eradication of Bovine Tuberculosis from Cattle in Denmark

Denmark, with some 1,600,000 dairy cows, has recently completed the eradication of bovine tuberculosis from among her herds, and is the first country in the world to guarantee that all exports of butter and cheese are from the milk of tubercle-free animals only. The occasion was marked by official celebrations in Copenhagen on June 13. The campaign was begun sixty years ago, when Prof. Bernhard Bang, of the Royal Veterinary College, Copenhagen, advocated the tuberculin-testing of all cattle, the isolation of the healthy animals, and the weeding out of reactors; its completion involved the slaughter of 318,000 reactors between 1934 and 1951 ("The Campaign against Bovine Tuberculosis in Denmark and its Eradication." By T. Mathiassen. Aarhus: by the Danish Federation of Dairy Associations. '*Re* Lur' branded butter and cheese: Order of Danish Ministry of Agriculture, March 27, 1952).

Ethics of Management

A striking article in the current issue of the *Journal of the Institute of Personnel Management* (34, No. 319) is one by the Institute's director, Mr. H. E. Roff, on the ethics of management. Accepting the four-fold aim of industry as the provision of goods and services, the earning of profit on capital, the provision of employment and the provision of social and work satisfaction, Roff suggests that management has responsibility to the customer, the shareholder, the employee and the community, the latter including responsibility for preserving the amenities of Britain, making effective use of natural resources, helping to produce democratic citizens and, finally, teaching the new generation of managers. The journal also contains an account of the workshop for elderly men at Rubery Owen and Co., an examination of the scientific study of human relations in industry, the report of a morale survey in a Danish department store, and the part played by trade unions in German industry. There are also some interesting notes on the training of shop stewards and the employment of older workers as well as the usual reviews of books and periodicals.

Imperial College of Science and Technology, London: Report for the Year 1950–51

The forty-fourth annual report of the Governing Body of the Imperial College of Science and Technology, London (pp. 55; from the College at South Kensington, London, S.W.7; 1951), covering the year ended July 31, 1951, refers to the further special grants of £3,000 made by the University Grants Committee in 1950–51 rising in 1951–52 to £4,000 for the provision of bursaries for postgraduate students in engineering. The first of the projected extensions to the chemical technology building and the new chemistry laboratories were completed during the year, adaptation of the Union building was nearing completion and the erection of laboratories for mineral dressing by adaptation of part of the Bessemer Laboratory is expected to be complete in August 1952. In spite of continuous progress in developments on the technological side, increasing costs have checked the steady advance in the quality and quantity of the work of the College during the first four years of the quinquennium. A deficit of more than £9,000 was incurred in 1949–50, and much larger deficits are anticipated in 1950–52. The finances have accordingly been closely examined to determine the directions in which economies are possible with the minimum reduction of efficiency. Capital grants from the University of London for new construction and equipment totalled £154,290; but room for expansion constitutes a serious problem. The plan for a South Kensington site has come no nearer to fruition; but the acquisition of the sites at 181–5 Queen's Gate and of the underlease of the property at 177 Queen's Gate should provide sufficient room for necessary normal development in the next five or ten years. Appendixes to the report include, besides the statement of accounts, a list of publications during 1950–51, arranged by departments.

Interpretation of Seismograms

Prior to the year 1930 seismologists were obliged to acquire information required for the interpretation of seismograms piecemeal from papers and portions of books on seismology, and from a careful study of their own particular instruments. In 1930 they became indebted to Dr. Frank Neumann, mathematician of the United States Coast and Geodetic Survey, for collecting these data and for making them available in mimeographed form. With the advance of the science of seismology it has now been necessary for Dr. Neumann to revise and enlarge his original work on this subject, and seismologists are now indebted to the Coast and Geodetic Survey for printing the work as Special Publication No. 254, "Principles Underlying the Interpretation of Seismograms". This work, which has been brought thoroughly up to date, is written for the Seismograph Station director, for the student who is beginning his career as a seismologist, or for the amateur seismologist. The reader is provided with basic background information pertaining to the origin and transmission of seismic waves and the recording characteristics of the principal types of seismographs now used in

the long-range detection of earthquakes, including short-period instruments. The established fundamentals of earth structure, upon which seismic wave propagation is dependent, are set forth, and travel-time tables for the major phases are discussed; graphs of the Gutenberg–Richter tables for four depths of earthquake focus, and published during 1934–39, are given. It is to be noted that an error of one second in determining the arrival time of the primary or *P* phase will result in epicentral distance errors ranging from 8 km. at a distance of 1,000 km. to 22 km. at a distance of 10,000 km. Rather more than ten years ago, Gutenberg and Richter introduced the earthquake magnitude scale, based on measurements of seismograms, to replace the earthquake intensity scales used previously. This logarithmic magnitude scale is described in detail. An increase of one unit in magnitude signifies a 63-fold increase in energy, and on the Gutenberg–Richter scale an earthquake of magnitude 5 would release 10^{21} ergs of energy. Copies of interpreted seismograms are given as illustrations in the publication.

The Blue Sun of September 1950

THE results of spectrophotometric observations of the blue sun, made at Edinburgh between 15h. 20m. and 15h. 25m. U.T. on September 26, 1950, have been described by R. Wilson (*Mon. Not. Roy. Astro. Soc.*, 111, 5; 1951). The 36-in. Cassegrain reflector of the Royal Observatory was used with the two-glass prism train of the attached Hilger universal spectrograph, giving the respective dispersions 132, 45 and 28 A./mm. at $H\alpha$, $H\beta$ and $H\gamma$. Very full details of the procedure and the deductions are given in the paper, at the end of which appears a summary of the conclusions. The layer causing the phenomenon was due to extensive forest fires in Alberta on September 23, 1950, the smoke from which was carried by upper winds to Europe, where the effect was quite different from that in America. Over the latter continent at various times and places there was complete darkness, and when the sun was visible it was purple or blue, while the scattered light in the sky produced shades of orange, purple or blue. Over Edinburgh on the afternoon of September 26 the smoke was observed, and the sun, seen quite clearly through the haze, was a deep indigo blue. According to E. M. Elsley (*Weather*, 6, 22; 1951), the scattering particles were globules of oil, caused by the distillation of wood, and the scattering theory predicted various features which were experimentally verified by Wilson's investigations. These particles were dielectric in nature and very homogeneous in size and constitution, and there appears to be the possibility that there was another system of particles in the layer, producing a neutral extinction. Using a relation deduced between the diameter and the refractive index of the scattering particles and assuming the latter to be about 1·5, which is near the value for most organic oils, the diameter of the particles would be of the order of one micron. If there was the other system of particles in the scattering layer, it is suggested that their most likely constitution was carbon, and it is possible that their size could be the same as that of the uniform dielectric particles. Communications in *Nature* of September 29, pp. 545 and 554, and December 22, p. 1086 (1951), also discussed this topic.

Exhibition of Geometry at Chicago

THE Illinois Institute of Technology has arranged an exhibition of geometry at the Chicago Museum of Science and Industry, and Prof. Karl Menger has written an attractive 34-page guide-book, with the title "You will like Geometry". The most striking feature of this is the large number of beautiful diagrams. The subjects treated are very varied. There are simple constructions of plane geometry, including some of a puzzle type which do not appear in the usual text-books. There is also a section on the regular solids, including Kepler's star-faced solids and Poinsot's star-cornered solids. Other parts of the guide book deal with more advanced mathematics, such as the theory of groups, which is introduced with reference to operations on triangles and other geometrical figures. An account is given of the 'universal curve', discovered by the author, which has the property that every curve of our space can be deformed into one of its parts. As the preface claims, "Geometry is amazing and ingenious and beautiful and profound; and, most important, it is alive and growing".

Announcements

'OPEN days' are being held at the Chemical Research Laboratory, Teddington, Middlesex, during September 23–26. Industrial firms wishing to send representatives and who are not already on the mailing list should apply to the Director, before August 31, for invitations for September 23 (afternoon), September 25 or 26 (morning or afternoon).

PAKISTAN'S first seismological research station is now being built in Quetta with the technical assistance of Unesco. The new service would be grateful for reprints of seismological papers published before 1948 and for back numbers of journals, which should be sent to the Pakistan Meteorological Service, Geophysical Division, Kings Road, Quetta, Pakistan.

MESSRS. BLUNDELL RULES, LTD., Chaul End Lane, Luton, Beds, have issued a small handbook of 22 pages (price 6*d.*) describing their range of slide rules, and giving examples of the uses of the various patterns. Thus, in addition to the usual rules in various styles graduated for simple mathematical operations, there are others with log–log scales, commercial calculators, electricians' scales with appropriate quantities, and a timber calculator. Most of these scales are made entirely of a white plastic material, based on vinyl chloride–vinylidene chloride copolymers, with a 'satin' finish. It is claimed to be resistant to water, most chemicals and fungi. It is strong, and the scales are sharp and clear; in some patterns the tension of the slide can be adjusted. Model A.G.1 (£1 13*s.*), a simple general-purpose rule, has the usual *A*, *B*, *C*, *D* scales, and also scales for reciprocals, cubes and mantissæ; additional red lines on the cursor provide for finding areas of circles of given diameter.

ERRATUM. In the communication entitled "Cellular Permeability of Yeast to Metallic Ions", by E. Quagliozzi and A. Rescigno, published in *Nature* of July 5, p. 35, the first equation should read:

$$\frac{V}{L}\frac{dx}{dt} = -v\frac{x}{Lb/V} + v\frac{(x_0 - x)\,V/L}{a};$$

and the second should read:

$$\frac{x}{x_0} = \frac{a \cdot \exp\left(-v\,\frac{a+b}{ab}\,t\right) + b}{a+b}.$$

The second reference in the footnote should be disregarded.

BIOSYNTHESIS OF CAROTENES IN RIPENING TOMATOES

By Dr. T. W. GOODWIN and MALINI JAMIKORN
Department of Biochemistry, University of Liverpool

PORTER and Lincoln[1] have recently put forward a theory of carotenogenesis in tomatoes. This scheme is based mainly on the results of pigment analyses carried out on the ripe fruit of various specially-bred crosses. From these a series of polyenes was obtained, differing from each other by four hydrogen atoms. As the members of the series could always be detected in every cross, it was postulated that the fully unsaturated carotene, lycopene, is formed from more saturated precursors by the stepwise removal of four hydrogen atoms, thus: perhydrophytoene → phytoene → phytofluene → ζ-carotene → neurosporene → lycopene. Lycopene is then assumed to become isomerized, in amounts varying according to variety, to α-, β- and γ-carotenes. The scheme was justified on genetic grounds. Porter and Lincoln emphasize, however, that a different mechanism may operate in other plant tissues such as green leaves.

The pioneer observation of Duggar[2], that ripening of excised tomatoes above 30° results in the inhibition of lycopene synthesis but not that of carotene, has frequently been confirmed[3]. Furthermore, as soon as the ripening temperature is reduced to 30° or below, lycopene synthesis is resumed and proceeds normally.

It was decided to find out what happened to the members of the Porter–Lincoln series other than lycopene when the synthesis of this latter carotene was inhibited by ripening excised tomatoes at high temperature. In particular, the variation in the phytofluene content was followed quantitatively, as this polyene occurs in reasonable amounts in ordinary commercial varieties, whereas most of the other members (for example, ζ-carotene and neurosporene) are only present in traces.

Methods and Results. Tomatoes were removed from the vine while still green as soon as the very first signs of ripening appeared. They were divided into four groups and these ripened at either 0°, 15°, 30° or 37°. Samples were taken for analysis once every three days for twelve days. The pigments were extracted and separated chromatographically according to the procedure recently described in detail by Goodwin[4]. α- and β-carotenes, lycopene and phytofluene were determined quantitatively, and the presence or absence of ζ-carotene and neurosporene was noted. Phytoene was never present in detectable amounts.

The results obtained are recorded in the accompanying table, from which the following conclusions can be drawn.

(1) It is confirmed that lycopene synthesis is inhibited at temperatures above 30°; there is, however, no concomitant accumulation of phytofluene or other members of the Porter–Lincoln series.

(2) The synthesis of the members of this series is equally inhibited under conditions inhibiting lycopene synthesis.

(3) Although all members of the series tend to appear together at the same stage of ripening, the rate of accumulation thereafter is not necessarily the same; for example, at 30°, from the ninth to the twelfth day of ripening, the amount of lycopene increases tenfold, whereas that of phytofluene is only doubled.

(4) The production of both α- and β-carotene is only slightly inhibited by ripening above 30°.

(5) Synthesis of all polyenes is inhibited in tomatoes held at 0°; but, again, that of lycopene most of all.

(6) No member of the Porter–Lincoln series is present in green (unripe) tomatoes.

Discussion. There seems little doubt from this and previous work that the major route of α- and β-carotene synthesis in normal tomatoes is a process entirely separate from the mechanism producing the Porter–Lincoln series. It is probable that α- and β-carotene can also be synthesized by a mechanism very similar to that producing the Porter–Lincoln series, but this can occur only to a very minor extent. The present results suggest that certainly not more than 15 per cent is formed in this way; but further observations are required before an accurate assessment can be made. Additional evidence that carotene can be produced in tomatoes by this second route comes from the results of Kohler, Lincoln, Porter, Zscheile, Caldwell, Harper and Silver[5], who produced a cross in which the carotene content of the ripe fruit was increased from a normal value of about 6 μgm./gm. to 101 μgm./gm.; this increase appeared to be almost entirely due to reduction of lycopene synthesis, for the total amount of carotenes present was not altered. Accepting the biosynthetic mechanism postulated by Porter and Lincoln, breeding in

Synthesis of Polyenes in Tomatoes ripened at Different Temperatures

	Amount present (μgm./gm. wet wt.) 3 days ripened	6 days ripened	9 days ripened	12 days ripened
Ripening temperature, 0°				
Lycopene	0	0·13	0·28	2·19
α-Carotene	0·20	0·25	0·34	0·51
β-Carotene	0·86	1·06	1·08	3·14
Phytofluene	0	?	?	1·14
ζ-Carotene, Neurosporene	absent	not detectable	not detectable	present
Ripening temperature, 15°				
Lycopene	0	6·6*	5·74	26·4
α-Carotene	0·11	0·76	0·97	0·93
β-Carotene	0·76	5·34	3·70	6·34
Phytofluene	0	1·16	2·17	2·44
ζ-Carotene, Neurosporene	absent	present	present	present
Ripening temperature, 30°				
Lycopene	0·39	—	2·52	25·2
α-Carotene	0·19	—	0·52	0·82
β-Carotene	1·11	—	2·78	6·75
Phytofluene	?	—	1·09	2·18
ζ-Carotene, Neurosporene	not detectable	—	present	present
Ripening temperature, 37°				
Lycopene	0	0	0·24	1·59
α-Carotene	0·17	0·32	0·66	0·47
β-Carotene	1·01	2·49	2·02	5·23
Phytofluene	0	0	?	?
ζ-Carotene, Neurosporene	absent	absent	not detectable	not detectable

* At 15°, the selection for six days was at a more advanced stage of ripeness than that for nine days.

this case can be assumed to have caused a shift in the equilibrium lycopene ⇌ β-carotene.

The question then arises: What mechanism exists for the production of most of the α- and β-carotene synthesis in tomatoes if the Porter–Lincoln pathway is only of minor importance? The most reasonable assumption at the moment is that the synthesis is due to a 'carry-over' of the mechanism operating in green leaves. This assumption is made highly likely for three reasons: (1) it is known that no member of the Porter–Lincoln series exists in green leaves and, therefore, the biosynthetic mechanism there is probably different; (2) unlike the synthesis of lycopene in tomatoes, that of carotene in tomatoes and in isolated leaves[6] is not significantly inhibited by temperature above 30°; and (3) at 0°, when the complete physiological ripening process in tomatoes is almost entirely inhibited, the synthesis of α- and β-carotene still continues to a significant extent in the green fruit whereas that of lycopene is negligible.

Furthermore, although the carotenoids present in fungi and the non-photosynthetic bacteria include the Porter–Lincoln series as well as β-carotene[7–9], the synthesis of β-carotene in, for example, *Phycomyces blakesleeanus* can be completely uncoupled from that of the Porter–Lincoln series[10]. In green leaves, as just stated, none of the Porter–Lincoln series occurs. This appears also to be true for the photosynthetic bacterium, *Rhodospirillum rubrum*. This organism produces only a single fully unsaturated carotenoid, spirilloxanthin (together with small amounts of *cis*-isomers)[11], and no evidence has yet been obtained of the presence of any member of the Porter–Lincoln series[12].

Although it is reasonable to assume that all the members of the Porter–Lincoln series are synthesized via very similar routes, there is as yet no conclusive biochemical evidence establishing the claim of Porter and Lincoln that the more saturated members are precursors of the more unsaturated ones. It is possible that the reactions proceed in the reverse direction to that envisaged, or that, as suggested by Goodwin[4], the members of the series are formed by a number of parallel syntheses which would not involve the utilization of any member as an intermediate in the formation of another.

Whatever the final outcome of experiments designed to test the stimulating hypothesis of Porter and Lincoln, it is clear that two mechanisms of carotenogenesis exist in ripening tomatoes. In one, the synthesis of most of the α- and β-carotene is achieved by a very similar mechanism to that occurring in green leaves; in the other, the synthesis of the Porter–Lincoln series occurs. The exact mechanism of both these processes is still almost completely unknown.

We wish to thank Messrs. A. H. Kitson and C. Rutherford for a gift of suitable tomatoes, and Prof. R. A. Morton for his continued interest in this work.

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INFLUENCE OF THIOUREA ON REPRODUCTION IN THE MINNOW

By Prof. E. J. W. BARRINGTON and A. J. MATTY
Department of Zoology, University of Nottingham

THERE has been accumulating considerable, if varied, evidence for the existence of some influence of the thyroid gland on the reproductive system of man[1], of other mammals[1–5] and of birds[6–8]. Evidence for such effects in the lower vertebrates, however, is much more limited and fragmentary, although it has been reported that thyroidectomy results in degeneration of the gonads in *Lacerta*[9] and *Triturus*[8]. Investigation of the situation in teleost fish has presented a particular difficulty, for the diffuse nature of the thyroid gland in that group has made surgical removal impracticable; but the discovery of anti-thyroid substances opened up the possibility of carrying out 'chemical thyroidectomy' by immersing fish in solutions of thiourea, and the use of this technique has produced some evidence of a retardation of growth and of the development of the external sexual characters in, for example, hybrids of *Platypœcilus maculatus* and *Xiphophorus hilleri*[10] and in *Lebistes reticulatus*[11].

In the course of an extended study of the thyroid gland of the minnow (*Phoxinus lævis*) we have kept a number of fish immersed in a 0·1 per cent solution of thiourea for several months under constant conditions of illumination and temperature (10° ± 2° C.), a control group being maintained under similar conditions in tap-water. It seemed likely from what was already known of the reproductive cycle of these fish[9] that an effect of the kind envisaged might be most readily demonstrated in the winter and early spring, and an initial experiment was accordingly begun on January 7, 1951. Little change took place in the thyroid gland during the first month of treatment; but by the end of the second month it was possible to demonstrate a substantial and statistically significant increase in the height of the follicle cells and a reduction in the internal diameter of the follicles, indication that the synthesis of thyroid hormone was being impeded in much the same way as it would be in mammals. At the end of 67 days treatment, all the fish appeared in good condition, as judged by appearance and by the 'condition factor', calculated from the weight/length relationship[12], and a number were therefore killed on March 15 for serial sectioning of the gonads. A comparison of seven control males with seven treated with thiourea, a number known to be adequate for yielding consistent results[9], showed that whereas spermatogenesis was far advanced in the seminiferous tubules, it had largely been arrested at the spermatocyte stage in the latter group, five members of which showed no sperm at all and two showed only traces of them. The situation in the females was less striking; but a comparison of the oocyte diameter, using the same number of animals, showed that those treated with thiourea were, in fact, smaller, the difference between the two groups being statistically significant.

Some animals, although fewer than could have been wished, were kept alive for 154 days, until June 10, by which time all eight members of a group of control animals had developed to varying degrees such external sexual characters as head tubercles and scarlet coloration. In marked contrast to this,

a group of nine animals treated with thiourea showed few signs of these; seven, for example, had no tubercles at all, and the other two had minute ones which could only be detected under magnification. The testis of the one male included in this latter group proved to be quite aberrant, lacking both sperm and stages of spermatogenesis, a condition difficult to interpret from a single specimen, but reminiscent of the "devastating" changes reported as occurring in the testes of thyroidectomized newts[13]; the testes of two control males were normal in appearance and full of sperm. The ovaries of four control females from this group, selected at random, were normal, with oocytes of a diameter approximating to those of mature eggs; but those of four females treated with thiourea possessed oocytes no larger than those of the 67-day fish: since, however, there were signs that these animals had not been feeding normally during the last four weeks of the experiment, we do not feel justified at this stage in attaching much weight to this last observation, although it is not necessarily lacking in significance.

While the results reported here seem to indicate a correlation between chemical thyroidectomy and a retardation of sexual activity in the minnow, they do not, of course, necessarily imply that the thyroid hormone normally exerts a direct influence upon the reproductive system of this animal; indeed, one cannot yet be certain that the consequences in fish of treatment with thiourea can legitimately be interpreted as physiological in nature. None the less, it is interesting to find increasing evidence of the existence of cyclical fluctuations in the activity of the thyroid gland of teleosts[14], related sometimes, it has been suggested, to spawning or to migration; and we ourselves, in work to be published elsewhere, have been able to demonstrate a statistically significant trend of increasing cell-height in the gland of the minnow during the winter and early summer. Our present knowledge of the endocrinology of the lower vertebrates is, however, so meagre that the significance of the facts is obscure in the extreme, and a discussion of them must be left for fuller treatment elsewhere.

In the meantime, one further point seems worth making. It has often been suggested that the apparent inhibiting influence of thyroidectomy on the reproductive system of the homothermous vertebrates might be a secondary consequence of reduced metabolic rate; in teleosts, however, such an explanation may prove to be less likely, for the available evidence, contradictory though it is in part, casts doubt on the existence of a marked calorigenic effect of the thyroid in that group. In studying such problems in fish, therefore, one may be analysing a simpler and, in evolutionary terms, more primitive situation than obtains in the higher forms, and it is hoped that work now in progress in this Department will test the correctness of this point of view. [Feb. 23.

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COMPETITIVE SUPPRESSION AND THE DETERMINATION OF LINKAGE IN MICRO-ORGANISMS

By J. L. JINKS

Agricultural Research Council's Unit of Biometrical Genetics, Department of Genetics, University of Birmingham

WHILE investigating the standard method of assessing the mutagenic activity of an agent by its enhancement of the back-mutation rate of strains of fungi carrying a biochemical mutation, Grigg[1] has demonstrated a marked suppression of the prototrophs (which arise from, and are used as a measure of, back mutation), by unchanged cells of the mutant strain, with which the experiment was started, and which are themselves incapable of growing on the medium used. Dilution of the spore suspension which was plated out gave an increase in the proportion of prototrophs recovered, presumably through a weakening of the suppression. Similar increases observed after treatment with reputed mutagens, which also kill a percentage of the spores, could therefore be due to a weakening of the suppressive effect and not to any rise in the back-mutation rate.

Kølmark and Westergaard[2] have shown that Grigg's criticisms do not apply to all tests of mutagenic activity made by the observation of back mutation, for on media containing excess nutrients competitive suppression does not occur. Indeed, it might be expected that competition will appear only where some nutrient is present in sufficiently small amounts for even the very limited activity of the non-prototrophs to cause its depletion. Since, however, suppression does occur under these, and possibly under other, so far unanalysed, conditions, it is essential for the correct interpretation of the results that, where such conditions are liable to be achieved experimentally, its effect should be recognized and its intensity evaluated.

Now clearly a similar suppression of prototrophs by spores themselves incapable of growth might occur where the prototrophs have come into being by means other than mutation. Techniques of demonstrating and estimating genetic linkages in micro-organisms are often dependent on the recovery of prototrophs, here arising by recombination of the genes in question, on selective media. In these cases, too, the prototrophs must grow in the presence of high concentrations of spores which, by virtue of their being non-recombinants or non-prototrophic recombinants, are incapable of growth. The recovery of the prototrophs, and hence the assessment of the linkages, might well, therefore, be disturbed by the occurrence of suppression similar to that which Grigg has found. Such a disturbance would be all the greater where, as in *Escherichia coli*, sexual fusion is itself rare, or where, as in the homothallic fungus *Aspergillus nidulans*, many of the fusions occur between nuclei of like genotype. In such species high concentrations of spores must often be plated in order to recover the prototrophs arising from the relatively rare fusion of nuclei of the appropriate types.

The occurrence of a suppression in *E. coli* is suggested by certain observations already in the literature, notably from studies of the effect of irradiation on recombination made by Haas, Wyss and Stone[3]. These authors used a concentrated inoculum, the cells coming from two strains which had complementary biochemical requirements. Only

the prototrophs arising by recombination would grow on the medium used. The numbers of prototrophs increased with time of exposure to radiation, up to a maximum of thirty seconds at which a large number of cells were killed.

These results were taken as showing an increase in recombination resulting from some unanalysed effect of the radiation. It would appear, however, to be explicable by the suppression effect as Grigg has described it. We merely have to make the further, and not unreasonable, postulate that suppression of prototrophs can be produced by mixtures of two or more non-prototrophic genotypes, as it can by a uniform sample of one such genotype. The lethal action of the radiation would lead to a reduced concentration of viable cells and hence a reduced suppression of prototrophs just as in Grigg's case.

Any lethal agency should, on this view, lead to a similar rise in the rate of recovery of prototrophs (and hence to a similar rise in apparent frequency of recombination), and indeed these same authors, in collaboration with Bennet-Clark[4], have shown that treatment of the spore suspensions with hydrogen peroxide (except where this is vitiated by pre-treatment with catalase) and sodium azide, both of them killing agents, produced just this result. True, above a certain level the treatments led to a decrease in the absolute number of prototrophs recovered; but this could arise at any point where the killing of the prototrophs themselves was no longer offset by a reduction in the suppression, as would be the case when the suspension had been thinned out below a certain level by the general lethal action of the treatment.

A further observation of these authors[5] also fits into the same picture. They found that after plating irradiated *Staphylococcus aureus* on to media containing streptomycin or penicillin the number of colonies formed increased with dilution of the cell suspension. They were able to offer no explanation of this result, but the interpretation is obvious in terms of suppression. The streptomycin- or penicillin-resistant colonies which develop are the equivalent of prototrophs and they are growing in the presence of large numbers of non-resistant cells which, of course, are inactivated by the antibiotic. Dilution would thus, as before, reduce the suppressive effect which one might suppose to exist.

Evidence of a similar nature is provided by Newcombe[6]. He found that concentrations of non-prototrophs higher than half those normally used in linkage estimations in *E. coli*, that is, 2×10^9, led to an apparent reduction in the rate of mutation of *E. coli* to bacteriophage resistance. This could be due to a suppression of the prototrophs, which are in this case the resistant mutants, by the large excess of non-prototrophs, and not to a reduction in the actual rate of mutation.

Finally, there is the evidence from an investigation by Nelson[7] into the relationship between the concentration of the two parental types mixed together, and the number of prototrophic recombinants produced in *E. coli*. Although in some cases the relationship was linear over the concentrations of parental types investigated, in others there was a marked falling off in the number of prototrophs recovered as the concentration of parental types increased. Extrapolation of one of the curves shows that at the concentration of parental types normally used in linkage estimations, approximately half the expected number of prototrophs would be recovered.

The investigations of Nelson illustrate a further point, namely, that the extent of suppression, if any, is specific for a particular prototroph – non-prototroph – concentration – medium combination. Therefore, if more than one type of prototroph is selected for in the presence of a mixture of non-prototrophs, by a particular medium, there is the possibility of differential suppression of the prototrophs. If this is true, one would expect the different prototrophs, or combinations of genes in an individual, to be recovered with different frequencies according to the particular character used as a basis for selection, as this will alter not only the types of prototrophs but also the types of non-prototrophs and the ratio of prototrophs to non-prototrophs. It is significant in this respect that Newcombe and Nyholm[8] obtained different linkage relations for non-selected characters according to whether they selected the prototrophs for their ability to grow on a minimal medium or for particular streptomycin reactions of the recombinants.

Thus there is a large body of evidence suggesting that the type of suppression reported by Grigg occurs in these micro-organisms whenever prototrophs are selected in the presence of large numbers of non-prototrophs. Furthermore, this suppression appears to occur no matter whether the prototrophs are selected by their ability to grow on a particular minimal medium, or for their resistance to, or requirement of, a particular drug, their ability to tolerate poisons, or their resistance to a bacteriophage.

In fungi, linkage experiments depending on the complete analysis of tetrads, or asci, must be above suspicion of this particular type of disturbance; but mass analysis of sexual spores, such as ascospores, or conidia, by a series of screening media will open the way to upset by competitive suppression. Such disturbance is likely to be all the more serious when the prototrophs are rare, for example, when recombination between tightly linked genes is being investigated, for in these cases heavier inocula of spores are generally plated in order to secure a reasonable number of the rare recombinants.

The operation of competitive suppression of the type discussed above would make true linkage appear tighter than is actually the case, while genes which really recombine freely might appear linked.

The literature on the genetics of *E. coli* abounds with reports of anomalous segregations and apparent non-linear arrangements of genes. Since the linkage estimations are normally made by the recovery of prototrophs from inocula carrying 10^8 or 10^9 of each parental type of cell per ml., it may well be that they merely reflect the widespread occurrence of the Grigg phenomenon. Certainly until this point has been cleared up the observations cannot be taken as incompatible with a chromosome system of the conventional kind (though, of course, the justification for postulating such a system in bacteria is perhaps another matter); and the more complex the screening technique used for the analysis, the more involved the competitive systems and the more confusing the effects of suppression might be.

Should the Grigg phenomenon turn out to be a source of complication in such linkage experiments, it is not easy to see a simple way of avoiding its effects. To keep the spore concentration constant in any set of determinations is an obvious elaboration of the standard technique; but this could not be relied on to do more than stabilize the disturbance so that a correction, which must itself be obtained from other considerations, could be applied. The correc-

tion, or the spore concentration, might well, however, have to be varied between the experiments involving different genes, for there is evidence that non-prototrophs of different kinds may not show the same strength of suppression on the various prototrophic recombinants. The only sure way round the difficulty would be the possibly tedious and demanding method of always using concentrations at which suppression does not occur or at least is negligible.

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INTERNATIONAL HEALTH ORGANIZATIONS

By Sir ARTHUR MacNALTY, K.C.B.

PESTILENCE has ever been a stimulus to preventive medicine. The dire visitations of cholera in Great Britain led to Snow and Budd's discoveries that water conveyed the disease and later to Koch's discovery of the *Cholera vibrio*. As international communications increased, so did the risk of transmission of disease from country to country. The principles of collaboration between governments in matters of health, established by the first international conference in 1851, led to further international sanitary conferences, the first general convention on quarantine in 1903, and the founding of the first international health organization, the Office International d'Hygiène Publique, at Paris in 1907. The Office carried on the work of the former Constantinople Superior Board of Health in preventing the spread of cholera by Mahommedan pilgrims to the holy places of Arabia. It also supplied important epidemiological information and data to fifty countries and secured international agreement on many medical and public health problems.

In all this work, Great Britain, the pioneer in public health, often took the initiative and placed her experience and knowledge at the service of other countries. Nor, since the beginning of the century, has the United States been far behind in this respect. The Pan-American Sanitary Bureau was founded by an International American Conference in 1901, and the First Pan-American Sanitary Conference in 1902 organized its work. Under the able directorship (1920–46) of Surgeon-General Hugh S. Cumming, and, afterwards, under that of Dr. Fred L. Soper, the Bureau's activities expanded to cover all aspects of public health of concern to the American republics. From co-operating closely with the Paris office as an information bureau which promptly reported outbreaks of certain epidemic diseases of international importance, it has become a central health agency for all American countries, and, on request, renders such aid as is possible to these countries in the prevention, control and eradication of disease.

The first example of international collective action against epidemic disease was seen after the First World War. There were big epidemics of typhus fever and other diseases in Poland, Russia, Roumania, Greece and other parts of Europe, and the threat of their spread was a serious menace. Through the League of Nations National Council, in May 1920, the Epidemic Commission was set up, and its team of international experts helped the countries concerned to get the epidemics under control.

The Covenant of the League of Nations contained a mandate to the League "to endeavour to take steps in matters of international concern for the prevention and control of disease (Article 23 (f) of the Covenant)". The Health Organization of the League began in 1921, and its constitution was finally adopted by the fourth assembly of the League in 1924. Dr. L. Rajchman (Poland) held the post of medical director from 1921 to January 1939. Its Health Committee was composed of the chief national health administrations, including the United States. Its secretariat comprised a number of medical men of different nationalities, public health officers and assistant staff.

The Health Organization's work met with success. It established close relations between the health services of different countries, gave information on public health questions and epidemics, promoted technical studies including international standardization, provided expert assistance in field investigations, organized study tours and set up a Far-Eastern Bureau in Singapore. The Organization was greatly helped by Sir George Buchanan, the British delegate to the Paris office and to all the International Sanitary Conferences during 1919–35, who recorded some of its achievements in his Milroy Lectures (1934); by Dr. M. T. Morgan, British delegate from 1936; by Prof. T. Madsen (Denmark), president of the Health Committee, 1921–37; by Prof. J. Parisot, president during 1937–47; and by many others.

During the Second World War co-operation on international health work was perforce restricted, and the Health Organization of the League of Nations was much reduced. When the War ended, in anticipation of threatened famine and severe epidemics, the United Nations Relief and Rehabilitation Administration was already in being. Though its duration was brief—it was dissolved in 1946—its labours controlled European epidemics, averted famine and supplied a temporary pressing need.

Following on the work of a technical preparatory committee which met in Paris during March–April 1946, a World Health Conference was held in New York in July of that year, attended by delegations from the fifty-one members of the United Nations, ten non-members, the Allied Control Commissions for Germany and Japan, and from ten international health organizations. As a result of this Conference, the World Health Organization was constituted and established. It has absorbed or integrated the work of previously existing international health organizations, set up its permanent headquarters at Geneva, and works in accord with the United Nations, the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization, the International Labour Office and other important bodies. An interim commission made preparations during 1946–48 for the permanent World Health Organization, continued the statutory func-

tions of the previous health organizations and conducted emergency health international work.

The objective of the World Health Organization is defined as "the attainment by all peoples of the highest possible level of health". For the time being, this high aim cannot be realized. Once more, international politics have placed obstacles in the way of world health. The U.S.S.R. and its satellites have withdrawn from the Organization, and the new government of China is not a member. With expenditure on armaments and national health services, there is little money available for helping and subsidizing the public health work of less progressive countries. The main work of the Organization seems, therefore, for the present to lie in epidemic intelligence, the making of international standards and the giving of expert advice, on request, to health administrations on public health matters. If disappointment be felt at this conclusion, when preventive medicine holds so many powerful weapons for the eradication of disease and suffering, it should be remembered that the work of the past hundred years has laid the foundations of international health, that much has been achieved, and that work of this character marks progress on the way to the time when all the nations of the world will unite for the good of mankind.

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BRITISH WELDING RESEARCH ASSOCIATION

NEW FATIGUE TESTING LABORATORY AT ABINGTON, CAMBRIDGE

MUCH is already known of the fatigue properties of structural steel and other industrial metals, when tested as simple laboratory specimens. Even so, it is essential to take into account the geometrical and metallurgical notches introduced into structures by welding or other methods of fabrication if fatigue failures are to be avoided. Because of this, the fatigue testing of welded structural components forms an important part of the work of the British Welding Research Association at its Engineering Research Station at Abington, near Cambridge. This work has received new impetus with the completion of a new Fatigue Testing Laboratory, officially opened by Lord Woolton, Lord President of the Council, on June 23. The new laboratory, which has a floor area of 5,000 sq. ft., is of technical interest in itself, since it is the first building to be erected for which the plastic design method, originated by Prof. J. F. Baker, professor of mechanical sciences in the University of Cambridge, has been applied. Appreciable economies in steel have been effected thereby, and the architect and consulting engineers have been enabled to produce an æsthetically pleasing building in which the steelwork is particularly unobtrusive.

The structural components which are tested come from the oil and power, aeronautical, shipbuilding, automobile and general engineering fields, and it is not surprising, therefore, that three broadly different methods of load application are used. Of these, the method of resonance vibration has been used for some years. The basis of this is the Lanchester oscillator, in which a pair of eccentrically mounted masses are rotated in opposite directions by means of a variable-speed motor, to produce an oscillating force in a given plane relative to the specimen, which is freely suspended at its nodes. When the speed is adjusted to a point near resonance, considerable stresses are set up in the specimen. In one case, fatigue bending tests have been carried out on light box members simulating chassis members in a motor-car, while, at the other extreme, tension/compression loads of ± 30 tons have been excited in Bailey bridge members, by the addition of masses at either end to establish the correct mode of vibration. Precise control of the induced stresses is important, and is achieved by speed control, using either amplitude of vibration or strain, through a wire-resistance strain-gauge, as the variable governing the servomechanism.

The resonance method is flexible in its application to varieties of structure, but has the disadvantages of producing only equal tension and compression load-cycles, and a severe size limitation caused by the rate of wear of large oscillators. The Association has therefore acquired two non-resonating machines of 100 tons capacity for installation in the new laboratory. The Losenhausen machine, with mechanical and hydraulic actuation, works at speeds of 100–600 cycles per min. (compared with more than 3,000 cycles per min. for a resonance machine). An interesting feature is its mounting on twenty-four struts, the Euler crippling load of which has just been exceeded, so that they behave as soft springs, ensuring that no vibrations from the 20 tons mass of the machine are communicated to the foundation. This method of mounting was developed by T. S. Robertson, of the Naval Construction Research Establishment, Rosyth. The other machine was designed by Prof. W. M. Wilson, of the University of Illinois, and is operated by means of an eccentric and a load-multiplying lever. Two specimens may be tested independently and simultaneously in this machine, but only at 100 cycles per minute. Parts for this machine have been made in Great Britain and given to the Association by a number of manufacturers interested in furthering the work of fatigue testing. Both the Illinois and Losenhausen machines make provision for statically preloading the specimen during test, so that load-cycles to the extremes of zero to maximum tension or compression may be applied.

The remaining fatigue-testing machine operated by the Association is concerned with pressure vessels and pipeline components subjected to internal pressure. This consists of a large-capacity hydraulic pump, together with automatic valve gear designed to apply pressure pulsations from atmospheric to 6,000 lb./sq. in. at up to 100 cycles per min.

The method of fatigue testing is attractive, even for structural members which may not be subject to severe pulsating loads during service, because of the searching comparison which may be made between types of weld and methods of design. Proneness to failure through the effect of stress concentration is exposed where static loads would be sustained with full ductility.

In parallel with the full programme of fatigue testing at present being carried out by the staff of the laboratory, studies are being made of the mechanics of crack propagation, the phenomenon which is fundamental to brittle and fatigue structural failures.

A. A. Wells

THE BEHAVIOUR OF BOWER-BIRDS

A COMMUNICATION by Prof. Evelyn Hutchinson, of Yale University, in a recent issue of the *American Scientist* (**40**, No. 1) throws considerable light upon the behaviour of bower-birds. The bower-birds are a group of Australian and New Guinea birds, generally classified along with the rifle-birds, Australian catbirds, and birds of paradise as the family Paradiseidæ, or pair of families, the Paradiseidæ and Ptilinorhynchidæ, which most ornithologists have regarded as closely allied to the crows. Though they lack the resplendent plumes of their allies, the birds of paradise, some of the bower-birds exhibit behaviour of a kind which in its complexity and refinement is unique in the non-human part of the animal kingdom.

The unique feature of the majority of bower-birds is that, during the breeding season, the males build tiny ceremonial houses, set neatly in clearings and furnished with a variety of objects which are used in display and which, when not in use, are piled up carefully on the cleared area in front of the bower. These bowers have nothing whatever to do with the nests of the species, which are constructed by the female alone at some little distance from the male's display area.

Hitherto this extraordinary type of behaviour has been interpreted anthropomorphically; but some recent papers permit the behaviour to be interpreted primarily in avian terms. The studies related mainly to two species, the tooth-billed bower-bird, *Scenopoeetes dentirostrist* and the satin bower-bird, *Ptilinorhynchus violaceus*. The former makes no true bower, though its behaviour is remarkable enough, while the latter not only builds a bower but also paints the inside of it, and so is perhaps one of the most advanced and complicated of all bower-birds in its habits.

Scenopoeetes is found only in a restricted area of north-eastern Queensland, living in tropical rain-forest. It is a dull-coloured bird about 27 cm. long and exhibits no external sexual dimorphism. The most remarkable morphological feature of *Scenopoeetes* is a triple saw-toothed apex to the maxilla, which fits into depressions at the apex of the mandible.

Like so many other male birds, the male *Scenopoeetes* occupies a definite territory during the breeding season, and from that territory he calls or sings. The central part of the territory, under the singing perch, is defined as a clearing, all the litter of the tropical forest floor being carefully taken away. On this clearing or stage, every morning the male *Scenopoeetes* arranges a number of leaves sawn off from neighbouring bushes and trees and placed with the pale conspicuous lower surfaces uppermost. Before this is done, the withered leaves of the previous day are carefully removed to a refuse pile outside the stage. The leaves are gathered by sawing through the petiole with the toothed tip of the beak. Not all species of bush or tree produce leaves which suit the tastes of *Scenopoeetes*, and individual males appear to have individual tastes in this matter. The leaves of *Alpinia* and *Darlingia*, which are often used, may be twice as long as the bird which collects and arranges them. The stage, which may be up to 2 m. × 3 m. in dimensions, can have more than forty leaves laid out on it. Although the toothed apex of the bill is not known to have any function other than that of sawing through leaf petioles, many of the leaves used can be easily detached by a sharp pull that would seem to be well within the physical capabilities of the bird. If *Scenopoeetes* had discovered this, its whole life might have been easier, though its evolution would probably have run a different course.

In *Ptilinorhynchus violaceus* there is a more elaborate type of behaviour. The bird is about the same size as *Scenopoeetes* and of normal form, but is strongly sexually dimorphic; both sexes have intensely blue eyes. The males do not acquire their adult plumage until they are at least five years old. This is a remarkable age for maturity in a passerine bird, for most species have a mean expectation of life at fledging of a little over a year, and show little change in survivorship from year to year, even when the potential physiological longevity may be ten or a dozen years.

The bower of *Ptilinorhynchus* is described as made of two parallel rows of sticks, each row being about 30 cm. high and 35 cm. long. The two rows lean towards each other, so producing an incomplete roof space. The long axis of this structure is normally set north and south, and in front of the north end a display area is cleared.

On the display area, a number of coloured objects are systematically arranged. The objects collected by *Ptilinorhynchus* are usually blue, less often lemon-yellow or greyish-brown. Throughout the entire breeding season, the male is likely to pick up one of these objects, moving in and out of the bower and displaying in front of the object by erecting the feathers and making characteristic movements. A female may be lurking behind the bower while this is happening; but the male appears to pay more attention to the blue flowers, berries, pieces of broken glass, or in some cases even street-car tickets, than to the blue eyes of the female.

The bower, therefore, cannot be involved in sexual selection as such, though, since the building habits develop each year in association with increasing testicular activity, the bowers and adjacent display areas with the associated coloured objects presumably have a sexual significance. It is probable that the blue and to a less extent the other coloured objects provide a greatly enhanced visual stimulation of the kind otherwise received from the blue eyes and possible other epigamic colouring of the female.

After mating, the female leaves the area of the bower and builds a nest by herself. Throughout the period of nest building and incubation the male continues displaying at the bower. During this period spermatogenesis continues actively, though in most single-brooded monogamous birds sperm production stops after mating and nidification. When the young are fledged, they are brought by the female to the bower and for a week or two the family engage in communal display activities. Then the bower is abandoned and all birds join the autumnal feeding flocks.

Some males of *Ptilinorhynchus* have the extraordinary habit of making a paint out of charcoal, or fruit pulp, mixed with a secretion produced from the mouth, and of applying this paint to the inside of the bower by means of a wad of fibre from some soft kind of bark. The habit is exhibited only at the height of the breeding season, when spermatogenesis is most active and mating and ovulation are occurring. The significance of this behaviour is entirely unknown.

The available information suggests that the extraordinarily specialized behaviour of the bower-birds is an immensely complicated development of avian territorialism. The chronology of the events in relation to spermatogenesis, no less than the detailed sequence of the behaviour itself, is in accord with this idea. The need for such behaviour arises from the fact that it is advantageous for any male to secure his territory and mate as early as possible, for competition is often severe, while it may be highly disadvantageous for reproduction to begin until much later in the year when adequate food for the young is available.

In addition to an elaboration of this kind, there is the extraordinary substitution of inanimate objects for the primary sexual stimulus, a process which would be termed fetishism in human psychopathology. This curious development directs attention to the way in which individual culturally determined acts in man so frequently have parallels in the specifically characteristic behaviour of birds.

HEALTH OF THE SCHOOL CHILD

IN "The Health of the School Child", the report for 1948–49 of the Chief Medical Officer to the Ministry of Education (London : H.M.S.O., 1952. Pp. 92. 3*s*. net), it is stated that the children in Great Britain are healthier than ever before in our history.

The numbers of under-nourished school children are now so small that school medical officers do not consider that the subject calls for special mention. Some of them, however, give data on heights and weights. Between 1939 and 1949, London school children gained an average of ¾ in. in height and 1¾ lb. in weight. A striking feature was that the changes in height and weight were proportionate ; while the greatest improvement had been in districts above average in 1938, there had also been a definite improvement in the worst areas. Children were not merely taller and heavier than their parents but were members of a generation altogether of greater physique. Figures relating to 5-year-old children in Wolverhampton showed that girls gained an average of over 6½ in. in height and more than 8 lb. in weight between 1909 and 1949 ; boys gained an average of nearly 4½ in. and 6½ lb. during the same period. Weighing machines in senior schools in this area were no longer adequate for pupils in their last year.

During the period 1939–49, the school meals service multiplied roughly seventeen times and had changed out of all recognition. With restrictions on the building of new canteens, the report suggests concentration on stabilizing and improving the existing service. The development of training courses for staffs at all levels is proposed. The lack of courses for women who serve the meals is unfortunate, particularly since reports on food poisoning frequently attributed the trouble to lack of knowledge in the canteens.

Figures for October 1949 showed that 53·2 per cent of the children present (2,851,000) took school dinners, and there were 23,000 canteens serving 27,000 schools. 1,950 schools were then without school meals facilities. In addition, 86·9 per cent (4¾ millions) of the children present took milk in school. More than 98 per cent of the milk was either tuberculin-tested or pasteurized.

During 1948, 96,262 school children had tonsil operations. The following year the figure fell to 69,449. The large number of operations in 1948—the figure was only exceeded in 1929–30–31—was mainly due to the widespread poliomyelitis epidemic in 1947. This caused the postponement of operations which would have been carried out in that year. The report stresses that tonsillectomy is scarcely ever an urgent operation and that only cases in need of urgent treatment should be referred to hospital for operative treatment. It is becoming increasingly realized that tonsillectomy is not a trivial operation and should not be treated lightly. Cases that are not urgent should be kept under observation for at least three months before being referred to a surgeon. All cases put on hospital lists should be examined periodically, since experience has shown that many who had been on a waiting list for a long time no longer required treatment. It is more important to deal safely and efficiently with a few children than to operate on large numbers, many of whom are in no need of urgent treatment.

The serious effect of the National Health Service on the school dental service is discussed. Because of the higher incomes obtainable under the new general dental service, many school dentists resigned to enter private practice. By the end of 1949, the number of school dental officers was 884 (equal to 732 full-time officers), compared with 1,063 (921 full-time) in 1947. In eighteen months, the service had lost one-fifth of its strength and was back to its war-time position.

There are signs in some areas that the improvement in the teeth of school children during and just after the War is on the wane. One report suggested that sticky buns given by mothers to restive young children was the possible cause of "the deplorable teeth so often seen in children between 5–7 years".

Nearly 450,000 school children (8 per cent of those on the registers) were found to be in a verminous condition in 1949. This was "profoundly disappointing" and showed no improvement on post-war years. In 1948, more than 4½ million school children —probably more than half of those on the registers— were medically examined or re-examined, other than for dental disease or verminous condition. The incidence figures for the various defects showed no major changes from those of 1947, though increases in the number of cases of defects of vision and speech needing treatment were recorded.

The new outlook on physical education is commented upon, and the growth of interest and skill in athletics noted. In Wales, athletics had made considerable headway where hitherto progress had been slow. The Midland and South-Western Divisions also reported an increase in the popularity of athletics ; in the North-Western Division it was "probably the one aspect of physical education in which improvement was most obvious".

The report contains a special chapter on the problems of diabetic children. England is believed to be the only country in the world providing hostels for these children ; but the report stresses that while such accommodation is indispensable for a minority of diabetic children, the great majority should remain at home since there was no substitute for a good home. The report also contains chapters on the co-ordination of the school health service with the National Health Service, the treatment of defective vision, and the prevention of tuberculosis in school children.

The cost of the school health service and special schools, which was £10,194,000 in 1947–48, fell to £9,234,000 in 1948–49.

INCENTIVES AND SIZE OF INDUSTRIAL PLANT IN GREAT BRITAIN

THE information about the "Proportion of Time-workers and Pieceworkers" which is published by the Ministry of Labour[1] may be expected to direct inquiries on industrial structure into new channels. A remarkable connexion between the distribution of pieceworkers and the variation of the size of plants emerges from this information, a connexion which in the past seems to have been overlooked by both theoretical and empirical studies in this field.

The first detailed survey of methods of wage payments in separate industries appeared in 1947; it was followed by two similar but more elaborate surveys, for October 1949 and October 1951. A new feature of these two is the classification of the data according to the size of industrial plants. Four size-classes are distinguished: establishments with less than 25, 25–99, 100–499, and with 500 or more wage-earners. Pieceworkers are defined as workers paid under any system of "payment by results", and data are supplied for 131 separate (mostly manufacturing) industries. The 1951 survey covers some 6¼ million workers, which amounts to more than two-thirds of the total number employed in the 131 industries.

To appreciate this material it should be recalled that the Census of Production gives data on size of plants and wages but not on wage methods. Although it might seem plausible that incentive schemes are more suitable for larger than for smaller plants, there has been no evidence of this. Indeed, it is known that they are widely used in such industries as cotton, potteries, dressmaking, etc., where relatively small and medium, rather than large, plants prevail. Thus, a close relationship between an industry's size-structure and particular payment methods could scarcely be expected. That it does exist, nevertheless, can now be seen from the Ministry of Labour surveys. We must exclude, of course, those industries where the proportion of pieceworkers as a whole is too small (say, less than 10 per cent) to be significant for the present purpose or where the information for separate size-classes is incomplete. There remain seventy-five industries, and forty-seven of these show a consistent relation between size-structure and incentives: the proportion of pieceworkers increases step by step with increasing size of plant. In iron and steel melting and rolling, for example, the percentage of piece-workers rises from class I (less than 25 workers) to class IV (500 and more), in 1949, as follows: 25, 37, 51 and 65 per cent; and similarly in 1951: 24, 41, 54 and 66 per cent. Other important industries with the same pattern are motor-vehicles, rayon and nylon weaving, building, boots and shoes, rubber, furniture and iron foundries. The industries which do not show a connexion between size of plant and methods of payment include woollen and worsted, cotton weaving, tailoring and agricultural machinery.

While a full explanation must wait for further data, two conclusions may already be suggested. The specific advantages of larger organizations are not only a matter of technical conditions, but involve also the opportunity of controlling a relatively larger number of workers through wage incentives; and the possibility of increasing the use of incentives, on the other hand, depends at least partly on the scope for expansion. There can be no doubt that the Ministry of Labour surveys are extremely useful for the advancement of research into these problems. It would be desirable, however, if in future actual figures of wage-earners, not merely percentages, could be supplied, and if the largest size-class could be split up into 500–999 and 1,000 and more workers. It would then be possible to link up the information with the Census of Production. W. Baldamus

[1] *Min. Lab. Gazette*, October 1947, October 1950 and April 1952.

EAST AFRICAN INDUSTRIAL RESEARCH BOARD

REPORT FOR 1951

THE ninth annual report of the East African Industrial Research Board* covers activities for the year ending December 31, 1951. Laboratory trials described in the last annual report have been followed by an experimental run at a factory producing sodium phosphate commercially, which has demonstrated that a satisfactory product can be obtained in a continuous chamber kiln fired by wood producer-gas, with proper control of firing. Storage trials over a period of three months have demonstrated that there is no deterioration of this type of product, provided there is no marked leaching.

The characteristics of cement clinker obtained by burning varying proportions of a product containing less than 0·5 per cent of phosphorus pentoxide, from limestone containing 2 per cent of phosphorus pentoxide, with raw limestone and clay are being investigated, and also the effect on refractory quality of bonding different grain-sizes of kyanite with various materials. Two new clay deposits have been found which proved satisfactory bond clays for refractories, and certain lavas have been found which can form the basis of a glaze for drain-pipes and which can be fired at a lower temperature than that required for salt glazing. The distillation of surplus wood from the wattle industry to give charcoal and wood tar is being investigated, and metallurgical charcoal obtained from wattle may be of use for smelting and other purposes in the Tororo area. Simple pulverization reduced the bulk density of the husk from dried coffee cherry sufficiently to permit its transportation for use as a substitute for bran in stock feeds. Mixed fatty acids obtained from the seeds of *Moringa oleifera* are highly suitable for froth flotation in the production of kyanite, and a drying oil which is satisfactory for paint manufacture has been obtained in 17 per cent yield from the whole nuts of *Aleurites triloba*, grown in Uganda, and in 55 per cent yield from the kernels.

Hecogenin, a steroid, which can be used as a raw material for the synthesis of cortisone, can be conveniently obtained from the juice of the sisal leaf, and a pilot plant has been built at the laboratory to provide the Medical Research Council with a supply of hecogenin for the synthesis of cortisone. A note appended to the report outlines the process and indicates the work which an officer of the National Institute for Medical Research is carrying out on the occurrence of hecogenin in sisal leaves. A note on the drying of sisal fibre and a list of publications on industrial research are also appended.

* East African Industrial Research Board. Ninth Annual Report, 1951. Pp. 10. (Nairobi: Government Printer, 1952.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Evidence for the Polarization of the Protons produced in the D—D Reaction

SEVERAL authors[1,2] have measured the angular distribution of the particles produced in the D—D reaction as a function of bombarding energy in the range 100–400 keV. A theoretical fit to the observations demonstrates the possibility of a strong spin-orbit coupling in the interaction[3]. This coupling may produce polarization of the outgoing protons[4]. The polarization can be detected by observing the azimuthal angular distribution of D—D particles scattered by nuclei in a process involving spin-orbit coupling. An azimuthal anisotropy would be proof of the polarization. Such an anisotropy has been demonstrated in a double-scattering experiment for protons of 3-meV. energy scattered by helium[5]. This provides a valuable analyser for the polarized proton. It was therefore decided to use this method in the search for a polarization of the protons produced in the D—D reaction. A previous attempt to detect polarization of the neutrons by scattering on carbon was vitiated by the background of neutrons produced by scattered deuterons in the accelerator tube.

A beam of 300-kV. deuterons was collimated by two diaphragms of 5-mm. diameter on to a heavy-ice target, thus producing 10^8 protons per second. Protons escaping at an angle of 120° to the deuteron beam were allowed to go through an aluminium window 6·5 mgm./cm.², and to pass through a scattering chamber (1·2 cm. diameter) containing helium at atmospheric pressure. The scattered protons were detected with a proportional counter (diameter 2 cm., length 7 cm.), filled to a pressure of one atmosphere with argon, at a distance of 2 cm. from the axis of the scattering volume, separated by an aluminium window (2·8 mgm./cm.²). Protons that had passed through an average of 4·0 cm. of helium and which were scattered through an angular range (75°–120° centre of mass) could enter the counter. At the moment of being scattered they had an energy of $(2 \pm 0{\cdot}2)$ MeV. Their energy on entering the counter was 600 keV., which is more than twice the maximum energy of argon recoils from the 2·5-MeV. neutrons. The walls of the counter were lined with lead in order to avoid a background of protons due to an (n,p) reaction which a brass wall counter was found to give.

The whole arrangement of scattering volume and counter could be rotated around the axis of the scattering chamber.

The centre of the scattering volume was 7·5 cm. from the target, which was aligned at 60° to the deuteron beam. The copper target was cooled with liquid air, and heavy ice was formed on it continuously. The size of the copper target was such that displacements of the incident deuteron beam could not cause serious asymmetries in the intensity of the proton beam in the scattering chamber. The measurements were monitored with a neutron recoil counter (filled with methane at 20 atmospheres pressure). The ratio of the intensity of scattered protons to neutron monitor counts was found to be constant within the statistical accuracy of 5 per cent, for any one orientation of the scattering chamber. The proton counting-rate was measured forward and backward in the plane of incident deuteron and emitted proton beams, and in the two positions normal to this plane. The rates observed were:

Forward	$1{\cdot}80 \pm 0{\cdot}07$
Backward	$2{\cdot}97 \pm 0{\cdot}11$
Normal positions	$2{\cdot}30 \pm 0{\cdot}08$, $2{\cdot}3 \pm 0{\cdot}09$

The azimuthal distribution is of the form $\sigma(\theta,\varphi) = \sigma[1 + PA\cos\varphi)$, where φ is the angle between the normals to the scattering planes. The magnitude of A is estimated from the geometry of this experiment and an average value for the analyser efficiency[5] of 87 per cent obtained. The product PA is evaluated from the above data and equation, correcting for the range of φ accepted by the counter. The value of PA is $0{\cdot}25 \pm 0{\cdot}05$. The analyser efficiency A is 0·87 for our geometry, with an uncertainty due to the experimental errors on the data obtained for p—He scattering. Thus the polarization of the D—D protons is (30 ± 6) per cent.

The symmetry of the D—D reaction for proton and neutron emission leads one to expect a similar degree of neutron polarization. Longley, Little and Slye[6] have reported a polarization of (40 ± 20) per cent for D—D neutrons. We cannot make a comparison with our result since they do not indicate the energy of their deuteron beam.

The interest of the availability of a source of polarized neutrons and protons for the investigation of spin-orbit coupling in nuclear scattering and of the interaction of polarized particles with polarized nuclei is obvious.

We are much obliged to Dr. R. J. Blin-Stoyle for suggesting this experiment to us, and for many stimulating discussions. We thank Lord Cherwell for his continued interest. One of us is indebted to Imperial Chemical Industries, Ltd., for a research fellowship, and another to the Department of Scientific and Industrial Research for a maintenance grant.

G. R. BISHOP J. M. WESTHEAD
G. PRESTON H. H. HALBAN

Clarendon Laboratory,
Oxford. June 23.

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Weak Echoes from the Ionosphere with Radio Waves of Frequency 1·42 Mc./s.

IT is well known that medium-frequency radio waves (0·5–1·5 Mc./s.) are often very highly absorbed in their passage through the lower ionosphere, so that the amplitude of the echo may fall below the limit of detectability of the usual ionospheric recording equipment. The occasions of greatest absorption occur in the day-time in summer, on certain days of abnormally great absorption in winter and for short intervals during radio fade-outs.

By the use of a new method, we have been able to improve the sensitivity very considerably and have been able to make measurements throughout days of high absorption in winter on a frequency of 1·42 Mc./s. It is the purpose of this communication

to outline the results obtained. The apparatus will be described in detail elsewhere. It is sufficient to state here that it uses a frequency-modulation method, which is a development of the original Appleton and Barrett frequency-change technique, and that special arrangements are made to integrate the output over a period of the order of 1 sec.

As in all 'radar' systems, the ultimate sensitivity depends on the mean power of the sender, provided the receiver is designed for optimum signal-to-noise ratio. With a pulse system the optimum signal-to-noise ratio could only be achieved by the use of pre-detector integration; it is not achieved with the ordinary type of pulse receiver. A comparison of our new system and the ordinary kind of pulse system may be made by stating that our mean power is 500 watts and our effective receiver band-width 1 c./s., whereas a typical high-power pulse apparatus uses a mean power of 100 watts (peak power 10 kw., pulse-width 200 sec., repetition frequency 50 c./s.) with a band-width of 20 kc./s.

It is easily possible with our apparatus in its present form to detect echoes corresponding to reflexion coefficients of 3×10^{-5} (attenuation 10 nepers).

Experiments on a frequency of 1·42 Mc./s. have been in progress since the beginning of the year. On several days of high absorption in January and February, when our colleagues, working with a pulse sender of frequency 2 Mc./s. and a peak power output 1 kw., were unable to detect any echo, waves of frequency 1·42 Mc./s. were observed to be reflected from heights between 75 km. and 80 km., and the effective reflexion coefficient was found by measurement to be less than 3×10^{-4}. On other days when the absorption was less, there were discrete reflexion heights near 90, 96 and 112 km., the latter height corresponding to the ordinary *E* region observed by our colleagues on a frequency of 2 Mc./s. These reflexion levels (75–80 km., 90–95 km. and 112 km.) appear to be the same as those observed by Naismith and Bramley[1] in measurements with waves of frequency 2 Mc./s. at oblique incidence. Since mid-March, the reflexion height has been consistently in the range 102–105 km., corresponding closely to the ordinary *E*-region reflexion. This height is still observed if the sender frequency is reduced to 1·025 Mc./s., so that there cannot be, at this time of year, any lower layer with electron density greater than about $1{\cdot}3 \times 10^4$ cm.$^{-3}$.

S. Gnanalingam
K. Weekes

Cavendish Laboratory,
Cambridge. May 30.

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Fine Structure of Chloroplasts in Two Flagellates

The structure of chloroplasts has been described in several recent reviews[1]. Previous information based on the use of the polarizing[2], ultra-violet[3] and electron microscopes[4] has provided some evidence that the chloroplasts have a lamellar structure. The electron microscope studies have been made exclusively on isolated plastids in which artefacts may be easily produced by disintegration and injury during the preparation of the specimens. The electron micrographs obtained have shown that the chloroplasts and even the grana consist of disks; but they have not yielded information about the orientation of these disks to one another. Progress in embedding and thin-sectioning techniques now permits us to examine in the electron microscope the structure of intact chloroplasts *in situ*. The present communication summarizes observations made by such methods on the chloroplasts of two algal flagellates, *Euglena gracilis bacillaris* and *Poteriochromonas stipitata* (a phagotrophic chrysomonad).

These flagellates were grown in chemically defined media[5] in light and in darkness. In light, they were deeply pigmented; in darkness they became completely colourless; this process was reversible. In the present study, in which they were grown under continuous light for four to seven days, both species contained elongated chloroplasts (1–2 μ in diameter and 5–10 μ in length for *Euglena*, smaller ones for the chrysomonad) which appeared faintly laminated in the phase-contrast microscope. For electron microscopy the flagellates were fixed in 1 per cent osmium tetroxide in 0·028 *M* acetate-veronal buffer, or in 0·21 *M* sucrose, embedded in *n*-butyl methacrylate, and sectioned at 0·05 μ (see ref. 6 for detailed techniques).

The electron micrographs of the sections of *Euglena* (Fig. 1) show that each chloroplast is approximately 1 μ in thickness, is limited by a membrane, and consists of a number (approximately twenty) of regularly oriented lamellæ. In cross-sections (Figs. 2 and 3) the lamellæ can be seen as dense bands, nearly uniform in thickness, and appearing to be continuous and homogeneous at the resolutions used. Measurements on fifty of these bands gave an average thickness of 250 A. (variations from 180 A. to 320 A.). The interlamellar spaces vary in thickness from 300 A. to 500 A. and contain a less-dense material that appears homogeneous except for occasional dense granules of 300–800 A. in diameter. Since there was no control on the angle of cutting, chloroplasts were frequently sectioned on the bias. Consequently, in such sections both the lamellæ and the interlamellar spaces show increased thickness. For this reason it is believed that the smallest values found for the thickness of the lamellæ are the more reliable. Additional factors appear to play a part in the variability of the spacing of the lamellæ; in poorly fixed material, they are frequently pulled apart and sometimes fractured. The most regular layering was found in material fixed by 1 per cent osmic acid in 0·21 *M* sucrose. A certain variability in the spacing of the lamellæ may indeed be present *in vivo* and explain the faint lamination seen in the phase-contrast microscope; obviously the lamellæ them-

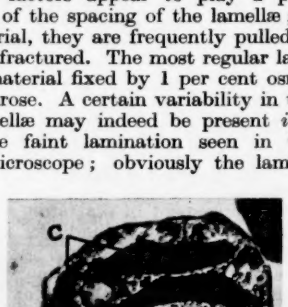

Fig. 1. Cross-section through the middle part of the body of a *Euglena*. *c*, chloroplasts (four organelles of this kind are visible in the section); *m*, mitochondria; *v*, vacuole; *n*, nucleus. The cuticle of the flagellate shows characteristic ridges. × 3,600

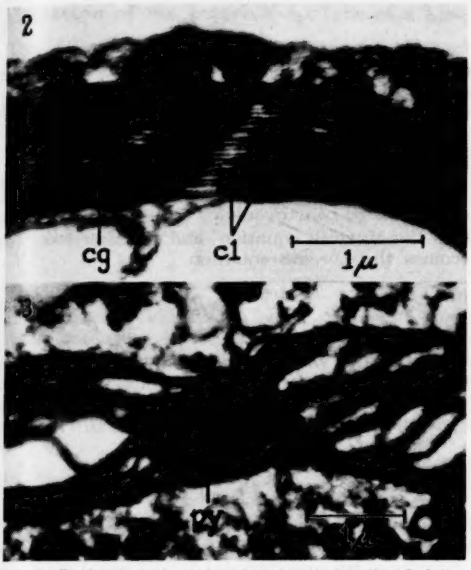

Fig. 2. Section through a chloroplast showing lamellæ (*cl*), interlamellar spaces and some chloroplast granules (*cg*). × 20,000
Fig. 3. Section through a chloroplast showing the pyrenoid (*py*). × 15,000

selves are below the limit of resolution of this instrument. Since the size of the chlorophyll molecule is below the limit of resolution of the electron microscope, nothing can be said at present about the location of chlorophyll in respect to the lamellæ.

A dense body found in the centre of the chloroplasts in some of our electron micrographs is interpreted as the pyrenoid ; it appears as a condensation of interlamellar material, with which it is frequently continuous. The lamellæ can be followed, in some cases, through the pyrenoid and appear to be tightly held together in this region (Fig. 3). In other instances, namely, in very dense pyrenoids, the lamellar structure seems to disappear at this level. A large cytoplasmic vacuole is frequently present outside the chloroplast in contact with the pyrenoid.

Chloroplasts with structure and organization similar to those of *Euglena* were found in *P. stipitata*. Further studies on the light versus dark reaction in the formation and structure of the chloroplasts are in progress ; a full account of this work will be reported and published elsewhere[7].

J. J. Wolken*
G. E. Palade

Rockefeller Institute for Medical Research,
New York 21. April 18.

* Fellow of the American Cancer Society on the recommendation of the Committee on Growth, National Research Council.

[1] Weier, T. E., and Stocking, C. R., *Bot. Rev.*, **18**, 14 (1952). Granick, S., "Photosynthesis in Plants" (edit. Franck and Loomis, Iowa State College Press, 1949). Frey-Wyssling, A., "Submicroscopic Morphology of Protoplasm and its Derivatives" (Elsevier Publishing Co., 1948). Rabinowitch, E. I., "Photosynthesis," **1** (Interscience Publishers, 1945).

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Screw Dislocations in Quartz

In a recent letter in *Nature*, Amelinckx[1] has given evidence for the existence of screw dislocations in mica. He observed a step, 140 A. high, which terminated on the surface : the point of termination of the step defined the point of emergence of a screw dislocation of Burgers's vector 140 A.

I have obtained similar evidence for the existence of screw dislocations in quartz. Fig. 1 is a photograph of the major rhombohedral face ($10\bar{1}1$) of a natural quartz crystal, showing the edges of growth sheets which have spread in two separate directions, denoted α and β in the figure. The α growth fronts are continuous, and parallel to the geographical contours of the face ; but the β growth fronts are discontinuous along the diagonal black line. This line is terminated on the surface at both ends, and is parallel to the line of intersection of the face with an adjacent major rhombohedral plane. Fig. 2 is the corresponding two-beam interference picture ($\lambda = 5460$ A.) of the area shown in Fig. 1, and shows that the diagonal line represents a step the height of which varies between 0 and 950 A.

It is well known[2] that the $\{10\bar{1}1\}$ major rhombohedral planes of quartz are planes of 'partial cleavage'. We can conclude that the diagonal line in Fig. 1 is a slip line, partial slip having taken place parallel to the major rhombohedral plane. The points of termination of the slip line, and the points along its length where a change of height occurs, mark the points of emergence of screw dislocations.

The slip line in Fig. 1 is much more visible than the growth fronts, although the latter are approximately 3000 A. high—that is, several times higher than the maximum height of the slip step. The reason for this reduced visibility of the growth fronts is that the risers of the growth fronts make a small angle (approximately 1°) with the plane surface of the growth sheets, whereas the slip line represents a sharp, vertical step.

I have observed a growth spiral on quartz, indicating that growth had taken place from a screw dislocation of Burgers's vector 220 A. This is therefore additional evidence for the existence of dislocations in the quartz lattice. It is hoped to publish a fuller account of the topography of quartz surfaces elsewhere.

Fig. 1. (× 7)

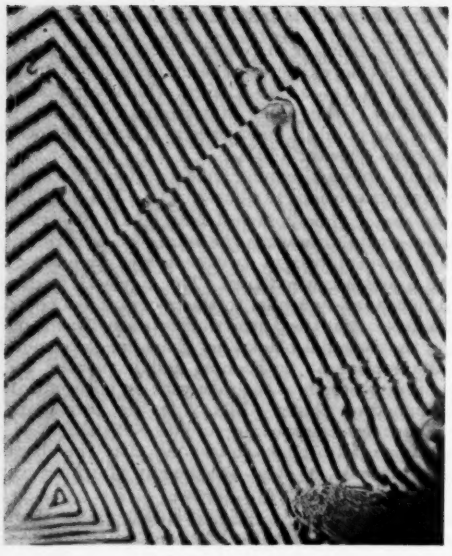

Fig. 2. (× 7)

I wish to thank Prof. S. Tolansky for his continual interest in this work; the Director, Signals Research and Development Establishment, Christchurch, for the loan of the crystal; and the Chief Scientist, Ministry of Supply, for permission to publish this account.

B. T. M. Willis

Royal Holloway College,
(University of London),
Englefield Green,
Surrey.
May 7.

[1] Amelinckx, S., *Nature*, **169**, 580 (1952).
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The Energy Momentum Tensor in Dirac's New Electromagnetic Theory

Dirac has recently[1] proposed a generalization of his new theory of electromagnetism so as to permit vortical streams of the electrical charge. The vortical motion has been introduced by redefining the potentials in a more general manner. Dirac has then framed two stationary principles, both of which lead back to the Lorentz equation of motion for an electric charge, with, however, the ratio, $m/e = k$, only occurring in it. The first of these stationary principles has for its action density

$$L = -\tfrac{1}{4}F_{\mu\nu}F_{\mu\nu} + \tfrac{1}{2}\lambda\,(v_\nu v_\nu - 1), \qquad (1)$$

where the potentials are assumed to be of the form

$$A_\mu = kv_\mu + \xi\frac{\partial\eta}{\partial x_\mu}. \qquad (2)$$

In these equations v_μ is the velocity vector, $v_\mu v_\mu = 1$, and ξ and η are two independent functions of the x_ν. λ is an arbitrary function of the x_ν. Varying the integral Lagrangian (1), one gets the equations,

$$v_\nu v_\nu = 1, \qquad (3)$$

$$k\frac{\partial F_{\mu\nu}}{\partial x_\nu} = \lambda v_\mu \qquad (4)$$

and

$$\frac{\partial F_{\mu\nu}}{\partial x_\nu}\frac{\partial\xi}{\partial x_\mu} = \frac{\partial F_{\mu\nu}}{\partial x_\nu}\frac{\partial\eta}{\partial x_\mu} = 0, \qquad (5)$$

so that

$$v_\mu\frac{\partial\xi}{\partial x_\mu} = v_\mu\frac{\partial\eta}{\partial x_\mu} = 0. \qquad (6)$$

(4) is the Maxwell equation, and (5) after reduction becomes the Lorentz equation

$$k\frac{\mathrm{d}v_\mu}{\mathrm{d}s} = v_\nu F_{\nu\mu}. \qquad (7)$$

In making the variation, the A_μ, ξ, η and λ were treated as the independent field functions.

The canonical energy momentum tensor $T_{\rho\sigma}$ derived in the standard way from the Lagrangian (1) is

$$T_{\rho\sigma} = \frac{\partial kv_\lambda}{\partial x_\sigma}F_{\rho\lambda} + \frac{\partial\xi}{\partial x_\sigma}F_{\rho\nu}\frac{\partial\eta}{\partial x_\nu} + \frac{\partial\eta}{\partial x_\sigma}F_{\mu\rho}\frac{\partial\xi}{\partial x_\mu} + \delta_{\rho\sigma}L. \qquad (8)$$

This tensor is not symmetrical and so with it angular momentum would not be conserved. To make it symmetrical we may proceed in the usual way (see, for example, Wentzel, "Quantum Theory of Fields", Appendix by Jauch) and add,

$$T'_{\rho\sigma} = -\frac{\partial}{\partial x_\lambda}(kv_\sigma F_{\rho\lambda}) = -\frac{\partial}{\partial x_\lambda}G_{\rho\lambda\sigma} = \frac{\partial}{\partial x_\lambda}G_{\lambda\rho\sigma}. \qquad (9)$$

$T'_{\rho\sigma}$ has the necessary properties of vanishing divergence and vanishing integrals of the energy and momentum components, for

$$\frac{\partial T'_{\rho\sigma}}{\partial x_\rho} = -\frac{\partial}{\partial x_\rho}\frac{\partial}{x_\lambda}G_{\rho\lambda\sigma} = 0,$$

$$\int T'_{4\sigma}\,\mathrm{d}x_1\mathrm{d}x_2\mathrm{d}x_3 = -\int\frac{\partial}{\partial x_\lambda}G_{4\lambda\sigma}\,\mathrm{d}x_1\mathrm{d}x_2\mathrm{d}x_3$$

$$= -\int\frac{\partial}{\partial x_k}G_{4k\sigma}\,\mathrm{d}x_1\mathrm{d}x_2\mathrm{d}x_3 = 0.$$

Now by (4),

$$T'_{\rho\sigma} = -\frac{\partial kv_\sigma}{\partial x_\lambda}F_{\rho\lambda} - kv_\sigma\frac{\partial F_{\rho\lambda}}{\partial x_\lambda} = \frac{\partial kv_\sigma}{\partial x_\lambda}F_{\rho\lambda} - v_\sigma\lambda v_\rho. \qquad (10)$$

So the symmetrical tensor, $\theta_{\rho\sigma} = \theta_{\sigma\rho}$, is

$$\theta_{\rho\sigma} = T_{\rho\sigma} + T'_{\rho\sigma} = F_{\sigma\lambda}F_{\rho\lambda} - v_\sigma\lambda v_\rho + \delta_{\rho\sigma}L. \qquad (11)$$

The ξ and η variables do not appear explicitly in this formula, and the tensor is, apart from notation, of the same form as the tensor of the irrotational theory, the θ_{00} and θ_{0k} components of which have been given by Le Couteur[2].

I thank Prof. P. A. M. Dirac for suggesting this problem to me.

S. F. B. Tyabji

Christ's College,
Cambridge.
May 20.

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Calculation of the Internal Surface of a Lung

THE following investigation arose out of work carried on in the Pathology Department of King's College, University of Durham, by Prof. J. B. Duguid and his colleagues, for which an estimate was needed of the respiratory surface area within a given volume of lung.

Tomkeieff[1] showed that, in a convex three-dimensional figure, the average linear intercept is equal to four times the volume divided by the surface area; that is,

$$\bar{l} = 4 \times \frac{\text{Volume}}{\text{Surface area}}.$$

If a number of similar such bodies, each of volume v and surface area A, are enclosed at random in a unit volume (V) and this volume is traversed by a number of lines of total length T, if also L is the total length of these lines which is interior to the convex bodies, and N is the number of intercepts, then

$$\frac{L}{T} \rightarrow \frac{\text{Volume of convex bodies}}{\text{Unit volume}} = \frac{L}{4NV} \times \Sigma(A),$$

and in the limit

$$\frac{\Sigma(A)}{V} = 4\,\frac{N}{T}.$$

Therefore, in the limit, the surface area per unit volume is equal to four times the number of intercepts divided by the total length of traverse.

It can further be shown that there is no necessity for imposing the restriction that the bodies should be similar to one another, or that they should be entirely enclosed in the unit volume. It is necessary, however, to postulate that the bodies should be randomly disposed towards the lines of traverse.

In the case of the internal surface area of a sample of a lung, the lung can be embedded in gelatine without shrinkage or distortion and cut in thin sections. These sections can then be scanned under a microscope, and all that is necessary to obtain the internal surface area is to count the number of intersections with cell walls that are made by the line of scanning and divide this number by two to give the number of intercepts. This scanning and counting can, in fact, be done electronically.

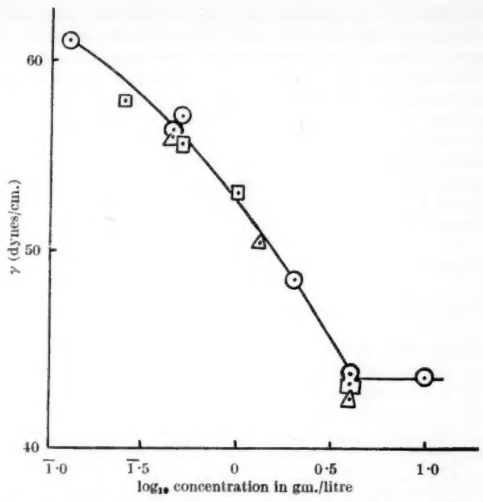
H. CAMPBELL
S. I. TOMKEIEFF

King's College,
University of Durham,
Newcastle upon Tyne.
April 3.

[1] *Nature*, **155**, 24 (1945); correction, p. 107.

Hæmolytic and Surface Activity of Sodium Taurocholate

IT is generally accepted that sodium taurocholate is a good lytic agent for erythrocytes, and a great number of reports on hæmolysis by this substance have been published[1]. Abnormal sigmoid time-dilution curves are sometimes reported for taurocholate lysis, and frequent reference is made to the instability of the taurocholate solutions used by these authors. One report[2] states qualitatively that a synthetic specimen of taurocholate was "moderately lytic", whereas a specimen prepared from natural sources was "strongly lytic". Two other reports[3] also give a much lower hæmolytic activity for taurocholate than that generally accepted.



γ – log c relation of sodium taurocholate in isotonic sodium chloride + boric acid buffer (0·02 M).
Line drawn as for pH 7, 20° C. ○, pH 7·0, 20° C.; ⊡, pH 7·0, 37° C.; △, pH 9·6, 37° C.

Through the generosity of Dr. Stenhagen, we have recently obtained a very pure specimen of sodium taurocholate, which has been examined for its hæmolytic and surface activity. Hæmolysis tests were made at 20° C. with a 5 per cent suspension of thrice-washed human erythrocytes (*AB,Rh*+) in 0·85 per cent sodium chloride buffered with 0·02 M boric acid, with borax added to pH 7·0. No lysis at all was observed overnight in concentrations of taurocholate up to 2·0 gm./lit. A solution of 11·0 gm./lit. effected complete lysis in approximately 30 hr., and one of 19·8 gm./lit. in 90 min. The lytic threshold for pure sodium taurocholate is therefore about 20 gm./lit. at 20° C. The values for human cells given in the papers already quoted are in the range of 0·10–0·15 gm./lit. for the lytic threshold. It is concluded that the previously accepted high lytic activity of sodium taurocholate is to be ascribed to the presence of impurities, perhaps long-chain fatty acids. The low activity of pure taurocholate has been confirmed by further experiments showing that a sample of natural taurocholate purified chromatographically and generously supplied by Dr. Pover has no lytic activity up to 3 gm./lit.

Determinations of surface tension were made at pH 7·0 and pH 9·5, and at 20° C. and 37° C. on solutions of Dr. Stenhagen's sample in the isotonic saline boric acid buffers described above. The Harkins drop-volume method was used in these determinations, with a glass-tipped tuberculin syringe operated by a micrometer screw. No decomposition of the test solutions was observed at room temperature, and in agreement with the opinion of Hutchinson[4], no surface tension ageing of the bile salt solutions was observed with this pure specimen. The results are given on a logarithmic concentration scale in the accompanying graph. The micelle point of the sodium taurocholate is 4·1 gm./lit. ($7{\cdot}4 \times 10^{-3}$ M) in this medium and the maximum micellar surface pressure is 29·3 dynes. A full report will be published elsewhere to show that solutions of surface-active

substances interacting weakly or not at all with cholesterol monolayers will lyse red cells strongly if their pressures are greater than 34 dynes. The strong hæmolytic activity previously reported for sodium taurocholate can now be ascribed to the lowering of the surface tension of solutions of the substance by surface-active impurities. The sigmoid time-dilution curves occasionally reported are interpreted as being caused by the zone of minimum surface tension produced by such impurities in solutions of micelle-forming surface-active substances[5].

B. A. Pethica

Department of Pharmacology,
Medical School,
University, Birmingham, 15.

J. H. Schulman

Department of Colloid Science,
Free School Lane,
Cambridge.

Jan. 18.

[1] Yeager, J. F., *J. Gen. Physiol.*, **11**, 779 (1928). Ponder, E., *J. Gen. Physiol.*, **28**, 349 (1945); *J. Exp. Biol.*, **23**, 350 (1947). Ponder, E., and Yeager, J. F., *J. Exp. Biol.*, **7**, 390 (1930). Bernheimer, A. W., *J. Gen. Physiol.*, **30**, 337 (1947). Shattuck, G. E., *J. Gen. Physiol.*, **12**, 17 (1928). Ponder, E., "Hæmolysis and Related Phenomena" (Grune and Stratton, New York, 1948).

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Flattening of Meniscus between Water and Organic Solvents

We have recently been carrying out experiments on the diffusion of solutes across the interface between water and organic solvents, using an optical method. In a cylindrical glass cell (2·4 cm. diameter) the meniscus is about 0·7 cm. deep, convex towards the water. This curvature would complicate the interpretation of diffusion measurements and would give a region on the organic solvent side where beams of light could not pass through undisturbed. If the tube is greasy, the meniscus is inverted.

It has been found possible to flatten this interface by a preliminary exposure of the inside of the tube to the vapours of 'Teddol', a preparation of the type Me_3SiF, which is strongly adsorbed on to the glass. A complete film would render the surface hydrophobic and give an inverted meniscus; but a suitably limited application gives a contact angle of 90°. In practice, it has been found more convenient to give a thorough treatment with 'Teddol' and then partially remove the film with a household metal polish on a test-tube brush. At intervals during the polishing the type of meniscus can be observed, until it is practically plane. When the interface is then formed, a very slight pressure on the liquid on one side or the other allows the final fine adjustment to a plane. With this technique it has been possible to cut down the gap in the light transmitted across the cell to less than 0·1 mm.

The surface formed is reasonably permanent, for the tube only needs re-treating at intervals of several months. It was shown that the optical properties of the tube were unaffected.

A. F. H. Ward
L. H. Brooks

Faculty of Technology,
University, Manchester.

April 25.

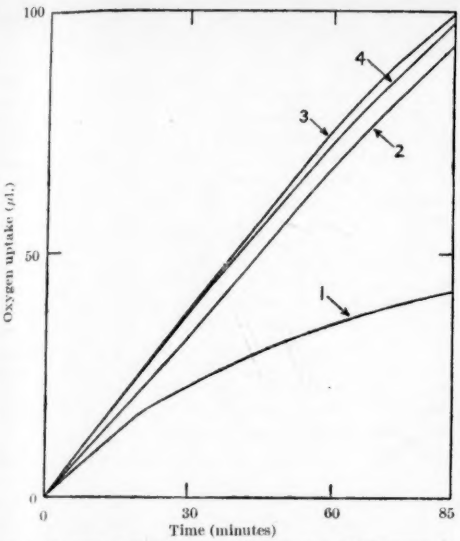
Stabilization of Oxidative Phosphorylation in Heart-Muscle Sarcosomes

Freshly prepared suspensions of the granular components of heart-muscle (sarcosomes[1], interstitial granules[2] or mitochondria[3]) are able to oxidize a number of intermediary metabolites, and to couple this oxidation with the synthesis of adenosine triphosphate from adenosine diphosphate and inorganic phosphate (oxidative phosphorylation)[4,5]. In agreement with the experience of other workers using preparations from different tissues, it has been found that the heart-muscle sarcosomes rapidly lose their ability to carry out oxidative phosphorylation, especially at temperatures above 0° C. Such aged preparations oxidize succinate at practically unimpaired rate, but the accompanying phosphorylation is lost. The ability to oxidize α-ketoglutarate is lost to about the same extent as the phosphorylation associated with this oxidation, so that the P : O ratio (the number of atoms of inorganic phosphate esterified per atom of oxygen consumed) is not greatly affected. The lability of rat heart sarcosomes is indicated by the following percentages of inactivation of the α-ketoglutaric oxidase system (the enzyme complex required for the aerobic oxidation of α-ketoglutarate to succinate): 10 min. standing at 15·5° C., 52 per cent inactivation; 15 min. at 25° C., 94 per cent inactivation. Cat preparations are somewhat more stable (15 min. standing at 25° C., 71 per cent inactivation).

These measurements were carried out with granules washed with isotonic phosphate-saline (0·135 *M* potassium chloride, 0·02 *M* phosphate, *p*H 7·4) and suspended in the same medium without further addition. The α-ketoglutaric oxidase system is much more stable in the presence of the reaction mixture used in oxidative phosphorylation experiments, the composition of which is given in the description to the accompanying graph. With cat heart sarcosomes, oxygen uptake and phosphorylation are maintained, under these conditions, at a uniform rate for 30 min. at 25° C.[5]. With rat heart preparations, on the other hand, the rate of oxygen uptake markedly declined after 15–20 min (see curve 1 of accompanying graph).

Since calcium is known to have a destructive effect on the morphology of sea urchin granules[6] and has also been shown to inhibit oxidative phosphorylation[7], the effect of the calcium-chelating agent, ethylenediaminetetracetate[8] (versene), was tried. Versene was found to protect, to a marked degree, the sarcosomal preparations from the morphological changes which occurred on standing. The accompanying graph (curves 2–4) shows that, in concentrations between 10^{-4} *M* and 2×10^{-3} *M*, it completely prevented the loss of activity of the α-ketoglutaric oxidase system which occurred with rat heart preparations even in the presence of the reaction mixture.

Versene, in higher concentrations, has an even more striking effect if it is added to the sarcosomal suspension during a preliminary incubation period before the preparation is added to the reaction mixture. For example, rat sarcosomes incubated for 15 min. at 25° C. in the absence of versene oxidized α-ketoglutarate at only 6 per cent of the rate of a control not given any preliminary incubation; both preparations were added to a reaction mixture containing 0·002 *M* versene. After incubation under the same conditions in the presence of 0·01 *M* versene, the preparation oxidized α-ketoglutarate at a rate



Effect of added versene on the oxidation of α-ketoglutarate by rat heart sarcosomes. Oxygen uptake measured manometrically in micro-flasks. All flasks contained, in a total volume of 1 ml., phosphate buffer, 0·036 *M*; potassium chloride, 0·026 *M*; sodium fluoride, 0·04 *M*; sodium malonate, 0·0089 *M*; glucose, 0·0167 *M*; adenosine monophosphate, 6×10^{-4} *M*; adenosine diphosphate, $6{\cdot}7 \times 10^{-4}$ *M*; cytochrome *c*, $3{\cdot}7 \times 10^{-6}$ *M*; magnesium, 0·005 *M*; α-ketoglutarate, 0·0074 *M*; sarcosomal preparation (1·4 mgm. protein) and hexokinase. *p*H 7·4; temperature, 25° C. Curve 1, no versene; curve 2, 10^{-4} *M* versene; curve 3, 10^{-3} *M* versene; curve 4, 2×10^{-3} *M* versene. The sarcosomal preparation was added at zero time without previous incubation

equal to 109 per cent of the control. In a similar experiment using sarcosomes isolated from cat heart and a 30-min. incubation period, 91 per cent inactivation was found after incubation in the absence of versene and 8 per cent activation when 0·01 *M* versene was added prior to incubation. The activity of the α-ketoglutaric oxidase system of cat heart sarcosomes, isolated with and suspended in isotonic phosphate-chloride containing 0·01 *M* versene, was unchanged after one day at 0° C., whereas that of a similar preparation isolated without versene was lowered by 84 per cent. At the end of this period, nearly all the sarcosomes in the latter preparation showed morphological changes, while no change had occurred in the preparation made with versene. Oxidative phosphorylation associated with the oxidation of α-ketoglutarate and succinate were also protected by 0·01 *M* versene; 0·001 *M* versene also gave considerable, although incomplete, protection.

Since the reaction mixture contained 0·001–0·002 *M* versene in all cases (see graph), it is clear that although versene protects the enzyme systems from the inactivation caused by the incubation, it does not reverse such inactivation.

When the sarcosomes were isolated with an isotonic solution containing 0·01 *M* versene and the versene afterwards removed by sedimentation of the granules in the centrifuge and washing twice with 100 volumes of versene-free phosphate-chloride, the preparation ('washed versene' preparation of the accompanying table) was still relatively stable. Thus, such a preparation from rat heart was only 18–27 per cent inactivated by incubation for 15 min. at 25° C. As is shown in the table, the addition of calcium chloride increased the rate of inactivation. It also increased the rate of inactivation of a normal preparation in the absence of versene. It seems likely that versene stabilizes the preparations by virtue of its ability to remove calcium associated with the sarcosomes. The mechanism of the inactivation by calcium is not known.

Full details will be published elsewhere.

We wish to thank Prof. D. Keilin for his interest and advice. This work was carried out during the tenure of a grant from the Agricultural Research Council to one of us (E. C. S.), and of a Nuffield Dominion Fellowship to one of us (K. W. C.) during leave from the Department of Histology and Embryology, University of Sydney.

Note added in proof. The component of the reaction mixture chiefly responsible for the limited protection of the α-ketoglutaric oxidase system in the absence of versene is adenosine diphosphate. This is in agreement with recent work of Kielley and Kielley[9]. Magnesium, fluoride and phosphate together, but not singly or in pairs, also give considerable protection.

E. C. Slater
K. W. Cleland

Molteno Institute,
University of Cambridge.
Jan. 28.

Effect of Calcium Chloride on the Inactivation of α-Ketoglutaric Oxidase System by Incubation

Exp.	Preparation	Incubation		Conc. of calcium chloride added (*M*)	Inactivation (per cent)
		Time (min.)	Temperature (° C.)		
1	Washed versene	15	25	0	18
				0·000033	4
				0·000067	38
				0·0002	33
				0·00067	58
				0·0067	79
2	Washed versene	15	25	0	27
				0·001	72
				0·01	84
		5	17	0	11
				0·01	56
3	Normal	5	15	0	18
				0·001	37
				0·01	44

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Glucose-6-Phosphate Dehydrogenase Activity of Rat Liver

A method of assay of glucose-6-phosphate dehydrogenase in liver has been devised employing spectrophotometric measurement of the rate of reduction of triphosphopyridine nucleotide in suitably prepared liver homogenate supernatants. This is preferable to the determination of dehydrogenase activity in extracts of acetone-dried tissues[1], or to the use of unphysiological carriers such as brilliant cresyl blue, 2-6-dichlorophenolindophenol or phenazine methosulphate[2].

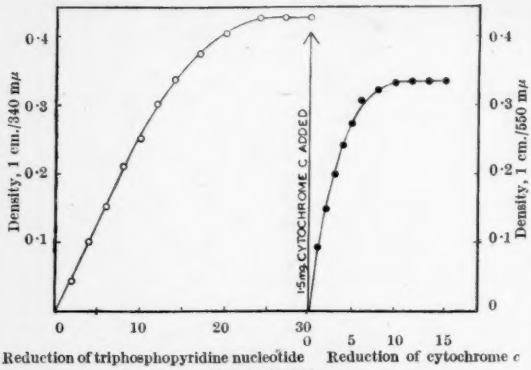

Fig. 1. The reduction of triphosphopyridine nucleotide by glucose-6-phosphate dehydrogenase coupled with the enzymic reduction of cytochrome *c*.

The initial reaction mixture (total volume 2·5 ml.) included 0·1 ml. rat liver supernatant and 0·5 ml. veronal-acetate buffer *p*H 7·4, ± 0·2 mgm. 70 per cent triphosphopyridine nucleotide. The reaction was started by the addition of 0·1 ml. of 0·05 *M* glucose-6-phosphate to both cells. When the reduction was complete, excess (1·5 mgm.) cytochrome *c* was added to both cells. Temperature 20° C.

Rat livers, chilled immediately after removal, were disintegrated in a Potter glass homogenizer in 4 volumes of ice-cold isotonic potassium chloride containing potassium bicarbonate to maintain the *p*H at 7·0, centrifuged for 60 min. at 4,000 *g* in an International refrigerated centrifuge and the supernatant dialysed overnight in the same cold extracting medium. This dialysed supernatant, which was free from triphosphopyridine nucleotidase and glucose-6-phosphatase, contained glucose-6-phosphate and 6-phosphogluconate-dehydrogenases and sufficient triphosphopyridine nucleotide–cytochrome *c* reductase[3] to be able to couple the reduction of triphosphopyridine nucleotide with that of cytochrome *c*. Results of a typical experiment with glucose-6-phosphate as substrate are given in Fig. 1. When the reduction of triphosphopyridine nucleotide was complete, excess cytochrome *c* was added and its reduction followed spectrophotometrically at 550 mμ. The rapid reduction of cytochrome *c* indicates that there are sufficient microsomes in suspension in the liver supernatant to provide triphosphopyridine nucleotide–cytochrome *c* reductase[4]. The reduction of triphosphopyridine nucleotide by the glucose-6-phosphate dehydrogenase system can also be coupled with the reduction of glutathione, as is indicated in Fig. 2 by the decrease in absorption at 340 mμ on addition of glutathione. This reaction is catalysed by glutathione reductase, which is associated with the combined soluble and microsome fractions of liver homogenates[5].

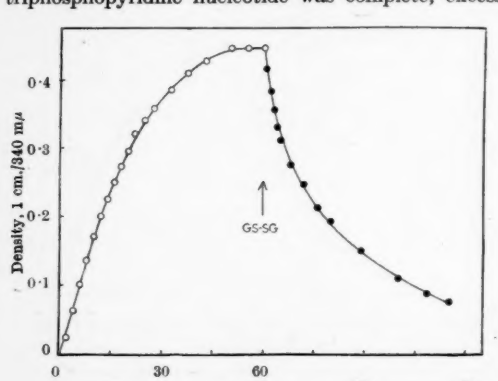

Fig. 2. The oxidation of reduced triphosphopyridine nucleotide by coupling glutathione reductase with glucose-6-phosphate dehydrogenase

The initial reaction mixture (total volume 2·5 ml.) included 0·1 ml. rat liver supernatant and 0·5 ml. veronal-acetate buffer *p*H 7·4, ± 0·2 mgm. 70 per cent triphosphopyridine nucleotide. The reaction was started by the addition of a limiting concentration of glucose-6-phosphate (0·1 ml. of 0·005 *M*). When the reaction was complete, 0·2 ml. of 0·025 *M* glutathione was added to both cells. Temperature 20° C.

The reduction of triphosphopyridine nucleotide at 20° by the glucose-6-phosphate dehydrogenase system in these liver supernatants is linear for approximately 15 min. and proportional to enzyme concentration over a sufficiently wide range to make this method applicable to the quantitative estimation of glucose-6-phosphate dehydrogenase in liver.

The $Q_{O_2}^{20°}$ per mgm. nitrogen for the glucose-6-phosphate dehydrogenase activity of seven pooled rat livers was 23·3, and the mean value and standard error on four individual rat livers was 21·15 ± 0·82. The mean (calculated) $Q_{O_2}^{37°}$ for the latter group is 72 and was increased to 106 on spinning for a further 15 min. at 20,000 *g*.

These values indicate that the level of glucose-6-phosphate dehydrogenase in liver is sufficient for this system to be of physiological significance, and indeed for there to be active competition between the glycolytic and direct oxidative pathways for glucose-6-phosphate, their common substrate. It is also of interest that the enzymes of both the glycolytic[6] and direct oxidative pathways appear to be present exclusively in the soluble fraction of liver homogenates.

This work will be reported in detail elsewhere.

G. E. Glock
P. McLean

Courtauld Institute of Biochemistry,
Middlesex Hospital, London, W.1.
April 28.

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Polynucleotides from Deoxyribonucleic Acids

Dinucleotides are found among the products of deoxyribonuclease digestion of deoxyribonucleic acids. By fractionation of the digest on ion-exchange resins, Sinsheimer and Koerner[1] isolated a dinucleotide containing deoxyadenylic and deoxycytidylic acids and one containing deoxycytidylic acid only. Smith and Markham[2] treated the deoxyribonuclease digest with phosphomonoesterase, thus removing the terminal phosphoryl groups of the polynucleotides, and fractionated the resulting products by paper chromatography in 70 per cent *iso*propanol–water (v/v) in an ammonia atmosphere (solvent 1) into seven bands (numbered 1–7 in order of increasing R_F values). From these, by paper electrophoresis in ammonium formate buffer *p*H 3·5, they isolated six dinucleoside

PROPERTIES OF SOME DINUCLEOSIDE MONOPHOSPHATE DIESTERS AND RELATED SUBSTANCES FROM DEOXYRIBONUCLEIC ACID

Substance	Adenine	Guanine	Cytosine	5-Methyl cytosine	Thymine	Position on chromatogram	Electrophoretic mobility at *p*H 3·5 (cm./2 hr. at 20 V./cm.)	Source of deoxyribonucleic acid
A–p–A	—	—	—	—	—	Band 5	4·2	Wheat embryo
A–p–G	1·05	0·95	—	—	—	„ 4	6·0	„
G–p–C	—	0·94	0·22	0·78	—	„ 4	3·0	„
G–p–MC								
A–p–C–p–T	0·97	—	1·03	—	1·00	„ 4	6·2	Herring sperm
A–p–C–p–T	1·05	—	0·92	0·10	0·93	„ 4	6·2	Wheat embryo
A–p–MC–p–T								

monophosphate diesters, *A–p–C*, *A–p–T*, *G–p–T*, *C–p–T*, *C–p–C* and *T–p–T* (where *A* = deoxyadenosine, *G* = deoxyguanosine, *C* = deoxycytidine, *T* = thymidine and *p* indicates a phosphoric acid residue giving two nucleosides). These originated from the corresponding dinucleotides in the deoxyribonuclease digest.

We have now isolated these and several other substances from similar digests of wheat embryo deoxyribonucleic acid. This acid was chosen because of its singularly high content of 5-methyl cytosine[3] and was prepared via the deoxyribonucleoproteins by the method of Mirsky and Pollister[4]. The digestion of the deoxyribonucleic acid with deoxyribonuclease and phosphomonoesterase and the isolation of substances from the digest by paper chromatography and electrophoresis have been described fully elsewhere[2]. Identification of the substances rests on (1) quantitative analysis for purines, pyrimidines[3] and phosphorus[5], which gives the molecular size directly, as after the removal of the terminal phosphoryl groups the compounds contain (*n*) nucleoside residues and (*n* − 1) phosphorus atoms; (2) rate of migration on paper electrophoresis at *p*H 3·5 [6]. The hitherto undescribed dinucleoside monophosphate diesters found are *A–p–A*, *A–p–G*, *G–p–C* and *G–p–MC* (*MC* = deoxy 5-methyl cytidine). *G–p–C* and *G–p–MC* could not be separated from each other by paper chromatography in neutral, acid or alkaline *iso*propanol–water mixtures and, of course, migrate together on electrophoresis. They occurred together in band 4 of that chromatogram in solvent 1, which on paper electrophoresis in 0·05 *M* ammonium formate buffer *p*H 3·5 gave several bands of substances including one with a movement of 4·2 cm. (2 hr. at 20 V./cm.). This on analysis contained 0·94 mole guanine/0·22 mole cytosine/0·78 mole 5-methyl cytosine/1 mole phosphorus. The molar ratio of total bases to phosphorus is 1·94/1 (theoretical ratio for a mixture of dinucleoside monophosphate diesters, 2/1), and the molar ratio of guanine to (cytosine + 5-methyl cytosine) is 0·94/1 (theoretical ratio for a mixture of *G–p–C* and *G–p–MC*, 1/1). Some properties of these substances are given in the accompanying table.

In similar digests from herring sperm deoxyribonucleic acid we have also found a substance containing equimolar proportions of adenine, cytosine and thymine which we consider to be *A–p–C–p–T*, *C–p–A–p–T*, *A–p–T–p–C* or a mixture of these isomers. In digests of wheat embryo deoxyribonucleic acid this substance occurs together with small quantities of *A–p–MC–p–T*, from which it has not been separated. It is a nucleoside ester of a dinucleotide derived from a trinucleotide.

Similar methods have been used for the isolation of several dinucleotides and one trinucleotide from deoxyribonuclease digests (*without* phosphomonoesterase treatment). On paper chromatography in solvent 1, the components of the digest are fractionated into three bands. From these by paper electrophoresis we have isolated the dinucleotides *AC*, *AT*, *CT*, *GT*, *CC* and *TT*, and a trinucleotide containing *A*, *C* and *T*. Treatment of these with phosphomonoesterase converts them to the corresponding substances of the type described above.

With purified diesterase from Russell viper venom[7], the dinucleotide *AC* gives a mixture of deoxyadenylic and deoxycytidylic acids, both of which are dephosphorylated by a specific 5′ nucleotidase, demonstrating that the terminal phosphoryl group of the dinucleotide is attached to the 5′ position on a deoxyriboside residue. If *A–p–C* (derived from *AC* by phosphomonoesterase action) is treated with the viper venom diesterase, it is slowly hydrolysed, yielding deoxycytidine and deoxyadenylic acid. The latter is entirely converted to deoxyadenosine by the specific 5′ nucleotidase from Russell viper venom and is therefore deoxyadenosine-5′-phosphate. The terminal phosphoryl group of *AC* is thus linked to the deoxycytidine residue, which in turn is joined by a phosphate ester link to the 5′ position on the deoxyadenosine residue. As there is no evidence for internucleotide linkages in deoxyribonucleic acid other than phosphate-sugar ester links, it follows that *AC* is deoxycytidine, 3′(deoxyadenosine-5′-phosphate) ester, 5′ phosphate, and the diesterase splits preferentially the 3′ phosphate ester link.

While our experiments have not yet led to any simple formulation of the action of deoxyribonuclease, they do suggest certain features in the arrangement of nucleotides in the nucleic acid chain, notably with respect to deoxycytidylic and 5-methyl deoxycytidylic acids. In complete deoxyribonuclease digests, the ratio *GMC*/*GC* is much higher than that found for any other pair of dinucleotides differing only in the replacement of cytosine by 5-methyl cytosine. We are inclined not to attribute this to a specificity of deoxyribonuclease, but rather to the position of the 5-methyl deoxycytidylic acid residues in the nucleic acid chain.

We wish to thank the Wellcome Research Laboratories for a generous gift of Russell viper venom.

J. D. SMITH
ROY MARKHAM

Agricultural Research Council
Plant Virus Research Unit,
Molteno Institute,
University of Cambridge.
April 22.

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Biochemical Differences between Red and White Muscle

Myoglobin, the principal pigment responsible for the red colour of muscle, was estimated by a method previously described by me[1]. The activities of components of the cytochrome system were determined in enzyme preparations[2] made from the muscles. Cytochrome oxidase was measured by determining the rates of oxidation of neutralized ascorbic acid in the presence of known amounts of added cytochrome *c* and extrapolating to infinite cytochrome *c* concentration[3]; succinic oxidase by the rate of oxidation of sodium succinate in the presence of excess cytochrome *c*[4]; and succinic dehydrogenase by the rate of reduction of methylene blue in the presence of excess sodium succinate, using the Thunberg technique[5]. Energy-rich phosphate (~ P), representing the sum of the labile phosphorus of adenosine triphosphate and of creatine phosphate, was determined as inorganic phosphate by Allen's method[6], after controlled hydrolysis of muscle extracts.

Both in Table 1, which represents data secured by analysis of muscle samples from the adults of various species, and in Table 2, in which are recorded figures for heart muscle from horses of different ages, it is evident that, in general, high myoglobin content in muscle is associated with high enzymic activity, particularly of cytochrome oxidase, in the corresponding enzyme preparations. This suggests that the function of myoglobin, with its power of reversible combination with oxygen and its low loading tension, is to assist in ensuring a constant supply of this element to the muscle oxidase system. The relatively low myoglobin content of horse heart and of pigeon breast muscle, despite high enzymic activity, may perhaps be explained by their possession of an excellent supply of oxygen from the blood, which is continually replenished by their characteristically repetitive contractions, thus partly dispensing with the need for an oxygen store. In contrast, the slow wing movements of the Manx shearwater, as compared with the more rapid ones of the pigeon, are reflected in a higher concentration of myoglobin in its pectoral muscle.

The other striking exception in the table to the general correspondence between myoglobin and the activity of the cytochrome system occurs in the psoas muscle of the blue whale. Its enzymic activity, which is very low in relation to the myoglobin content, helps to explain the diving capabilities of this mammal, for a low rate of oxygen utilization increases the length of time during which its relatively meagre store of myoglobin-bound oxygen could be effective. (When calculation is made to the same original weight of muscle, it is found that the whale psoas has an oxygen store at least twelve times greater, in relation to cytochrome oxidase activity, than that of the horse psoas.)

Table 1. Relation between Enzymic Activity in Muscle Preparations and Myoglobin Content in Corresponding Whole Muscle. Effect of Species and Type of Muscle

Muscle	Species	Myoglobin (% wet wt.)	Enzymic activity Q_{O_2} (μl. O_2/mgm. dry fat-free wt./hr.)		
			Succinic dehydrogenase	Succinic oxidase	Cytochrome oxidase
Psoas	Horse (mean of 6 animals)	0·71	80	260	1,700
Diaphragm		0·61	60	240	1,700
L. dorsi		0·47	30	140	900
Heart		0·33	210	610	2,800
Psoas	Blue whale	0·84	20	80	600
Psoas	Ox	0·60	40	160	1,200
Psoas	Elephant	0·46	30	140	800
Psoas	Pig	0·43	20	130	1,000
Psoas	Sheep	0·35	30	180	950
Psoas	Hare	0·16	30	110	650
Psoas	Rabbit	0·02	<10	60	250
Pectoral	Manx shearwater	0·69	50	230	1,800
Pectoral	Pigeon	0·22	50	260	2,300

Table 2. Effect of Age in Horse Heart Muscle

Age	Myoglobin (% wet wt.)	Enzymic activity Q_{O_2} (μl. O_2/mgm. dry fat-free wt./hr.)		
		Succinic dehydrogenase	Succinic oxidase	Cytochrome oxidase
5 months before birth	0·02	negligible	20	260
6 weeks before birth	0·10	60	160	1,560
18 months after birth	0·27	240	580	2,760
2–12 years after birth (Mean of 6 animals)	0·33	210	610	2,800

It may also be noted from Table 1 that the activities of succinic dehydrogenase and of succinic oxidase in heart muscle apparently represent a greater proportion of the cytochrome oxidase activity than is the case in skeletal muscle. Similarly, in horse heart muscle (Table 2), with increasing age, succinic dehydrogenase and oxidase show a proportionately greater increase than does cytochrome oxidase over the same period. Data (not reported here) for the psoas, longissimus dorsi and diaphragm muscles of the horse also show this effect.

Apart from the above correlation between redness (myoglobin) and the activity of the cytochrome system, other differences have been found between heart, red, and white musculature. In skeletal muscle, the following bear an inverse relation to myoglobin content: (1) the initial resting level of energy-rich phosphate; (2) the ratio of rate of fall of *p*H under aerobic conditions to that under anaerobic conditions, and the ratio of rate of aerobic to anaerobic breakdown of energy-rich phosphate in post-mortem catabolism; (3) the rate of *p*H fall under anaerobic conditions; and (4) the 'maximum'[7] adenosine triphosphatase activity ('resting'[7] adenosine triphosphatase activity is about the same, irrespective of myoglobin content.) In other words, the more myoglobin in skeletal muscle, the greater appears to be its capacity for respiratory metabolism and the less its power for carrying out glycolytic processes; and conversely. Heart muscle appears to be unique in showing a virtual absence of glycolytic mechanisms—there is no detectable fall of *p*H under anaerobic conditions (in fact, a slight rise is often evident) and negligible anaerobic breakdown of energy-rich phosphates in post-mortem catabolism; the resting level of energy-rich phosphate is, moreover, very low. Adenosine triphosphatase activity is also very small and appears to be the same in 'resting' and 'maximum' conditions of activity. Heart muscle thus shows a profound dependence on oxygen for its functioning, with little or no capacity for incurring an 'oxygen debt'.

It is hoped to publish a full account of this work elsewhere.

Thanks are due to Dr. L. Harrison Matthews and Dr. Osman Hill, of the Zoological Society, London; to Mr. R. W. Pomeroy, of the School of Agriculture, Cambridge; and to Dr. J. G. Sharp, Mr. J. R. Bendall and Mr. J. K. Walley, of the Low Temperature Research Station, Cambridge, for making avail-

able various muscle samples. The encouragement of Prof. D. Keilin throughout these investigations is gratefully acknowledged.

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R. A. LAWRIE

Low Temperature Station
for Research in Biochemistry and Biophysics,
University of Cambridge,
and
Department of Scientific and Industrial Research.

Jan. 7.

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Paper Electrophoresis of Serum Proteins

THE separation of the albumin, α_1-, α_2-, β- and γ-globulin fractions of serum protein can be accomplished by electrophoresis on filter paper[1-3]. The protein fractions are delineated as bands by drying the paper, and then staining with bromphenol blue. Cremer and Tiselius[2] estimated the fractions by elution of 5-mm. strips of the filter paper, the concentration of the dye from each strip being determined colorimetrically. A curve is thus obtained, similar to that from the classical Tiselius electrophoresis.

The separation by paper electrophoresis is elegant, and the apparatus simple, but the elution of dye from thirty to forty pieces of filter paper is both tedious and time-consuming, besides having theoretical objections. To simplify the procedure, and make it more adaptable for routine clinical laboratory analysis, we cut out, after staining, whole bands representing protein fractions and estimate the protein by Kjeldahl analysis of the filter paper. If an accurately measured amount of serum protein is used initially, the fractions are thus directly estimated in terms of protein nitrogen. This method gives duplicate results which appear to be as accurate as those obtained by the much longer procedure of elution. A comparison of the results of the analysis of a serum (converted into percentages of total protein) both by this method and that of the classical Tiselius separation is given herewith.

	Albumin	Globulins			
		α_1-	α_2-	β-	γ-
Paper electrophoresis	62·3	3·3	7·2	14·4	12·8
Tiselius electrophoresis (Veronal buffer, *p*H 8·6)	62·8	3·7	7·1	14·0	12·2

Full details of the method and the results obtained will be published elsewhere.

B. LEVIN
V. G. OBERHOLZER

Department of Pathology,
Queen Elizabeth Hospital for Children,
London.

Jan. 9.

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Inhibition of Lysine Decarboxylase from *E. coli* by Homologous Rabbit Antibody

IN studies on the production of antibodies to bacterial amino-acid decarboxylases, we have used lysine decarboxylase from a coliform organism as an antigen. This material was partially purified by a modification of the method of Gale and Epps[1] in order to reduce its toxicity for animals. The antigen, containing approximately 1·5 mgm. protein/ml., was injected intravenously into rabbits over a period of a month, at the rate of three injections a week. The dosage was gradually increased from 0·2 ml. to 1 ml. The rabbits were bled ten days after the final injection.

The antiserum was tested for inhibition of the lysine decarboxylase by the manometric method of Miller *et al.*[2]. Double side-arm Warburg flasks were employed, the antiserum being tipped in after the reaction had proceeded for twenty to thirty minutes. With the homologous enzyme, inhibition of decarboxylase activity was about 90 per cent complete. No inhibition of the corresponding glutamic acid decarboxylase preparations was noted, however, when antiserum to lysine decarboxylase was added under the same conditions.

When the antiserum and homologous enzyme were mixed and allowed to stand overnight in the refrigerator, a precipitate formed. The residual activity noted above was found only in the precipitate, showing that the enzyme is both precipitated and largely inhibited by the homologous antiserum. This positive finding is in contrast to the results recently reported by Happold and Ryden[3] for tyrosine decarboxylase from *Str. fæcalis*.

A more detailed report of these experiments will be made in a doctoral dissertation to be submitted to Yale University by one of us (A. F. H.).

ARTHUR F. HOWE
HENRY P. TREFFERS

Department of Microbiology,
Yale University, New Haven,
Connecticut. Feb. 21.

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Reported Gamma Glutamyl Activation of Peptide-Bond Synthesis

IN a recent paper in *Nature*, Hanes *et al.*[1] postulated a γ-glutamyl transfer mechanism in peptide bond synthesis. It is suggested that the amino-acid forms its first peptide bond with the γ-carboxyl of glutamic acid by displacing the cysteinyl glycine from glutathione. The amino-acid, now peptide bound, could be further transferred to other peptides. The concept is strengthened in view of the universal and yet unexplained presence of glutathione in all living tissues, the great significance of 'transferring' reactions in biochemistry, and the need for some hypothesis to shed light on the mechanism of protein synthesis. Experiments to test this hypothesis are described in this communication.

Labelled γ-glutamyl glycine was synthesized using a micro adaptation of the method of LeQuesne and Young[2]. 40 mgm. of doubly labelled glycine (2·5 μC./mgm.) yielded 25 mgm. of peptide, the purity of which was verified by elementary analysis (theoretical C,

41·2; H, 5·9; N, 13·7 per cent; found: radioactive C, 41·38; H, 6·01 per cent; cold C, 41·31; H, 5·91; N, 13·58 per cent). The uptake of free radioglycine was compared to that of glycine in the presence of glutamic acid, glutamine, glutathione, and cold γ-glutamyl glycine. The systems studied were cytoplasmic particulate matter from rat liver suspended in cell supernatant (*PS* system)[3], whole cells of mouse spleen[4], spleen homogenate, and the Gardner lymphosarcoma of *C3H* mice[4]. The uptake of radiovaline (2-^{14}C-labelled 3·2 μC./mgm.) in the presence of glutamic acid, glutamine and glutathione in the *PS* system[3] and that of radiophenylalanine (2·38 μC./mgm., 2-^{14}C-labelled) in the presence of glutamic acid, glutamine, glutathione, and cold γ-glutamyl glycine in rat kidney homogenate were also studied.

In no case was there any appreciable activation of amino-acid incorporation by γ-glutamyl compounds. The uptake of glycine from the peptide was always appreciably less efficient than that of free glycine. The *PS* system used the peptide glycine three and a half times more efficiently than the spleen whole cell or homogenate.

'Dowex 50' chromatography of the free and peptide glycine showed that, in the liver particulate system, the peptide is 88 per cent hydrolysed in 20 min. and completely hydrolysed in 60 min. In spleen whole cells, the peptide is comparatively stable, 2 per cent being hydrolysed in 20 min. and 5 per cent in 60 min. This demonstrates a dependence of glycine incorporation on hydrolysis of the peptide in these systems.

In incubations with radioglycine at 20 min. and at 60 min., and with radioglycine plus cold γ-glutamyl glycine at 20 min., no radioactive γ-glutamyl glycine was present in the supernatant fluids. The liver particulate and spleen whole cell systems were used.

It is interesting to note that their reported stability to intercellular peptidases[1] was considered as evidence in favour of γ-glutamyl intermediates. The exceedingly rapid hydrolysis of the peptide in liver seems to eliminate this possibility.

These results cannot be interpreted in favour of γ-glutamyl activation as an important mechanism in amino-acid incorporation. Fuller details will appear in a later publication.

Richard W. Hendler
David M. Greenberg

Division of Biochemistry,
School of Medicine,
University of California,
Berkeley 4, California.
Jan. 29.

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Purification of a Lipid Material ('Cord Factor') obtained from Young Cultures of Tubercle Bacilli

When young cultures of wet tubercle bacilli are mildly extracted with petroleum ether, a small quantity of a lipid material ('cord factor') is obtained[1]. The most characteristic biological property of this material is a delayed type of toxicity. Mice injected at three- to four-day intervals with 0·1 mgm. of the crude extract die after ten to fourteen days, severely emaciated and with hæmorrhages of the lungs. The crude material gives negative reactions for phosphorus[2] (sensitivity < 0·1 per cent phosphorus) and for nitrogen[3] (sensitivity < 0·4 per cent nitrogen).

The characteristic toxicity described was used as a biological test for the identification of the material during its further purification. The crude extract was repeatedly heated in acetone to the boiling point and the clear supernatant decanted immediately. Thus, an acetone-soluble fraction (*A*) is obtained, representing about 99 per cent of the total material. The residue which, under these conditions, remains undissolved (fraction *B*, about 1 per cent) shows the characteristic toxicity, whereas *A* is inactive. Fraction *A* consists chiefly of neutral constituents (mainly phthiocerol), mycolic and other acids, and carbohydrates. A detailed report on these constituents will be published. Fraction *B* is soluble in cold petroleum ether, benzene, chloroform and ether, and insoluble in methanol, ethanol and water. After heating it for about thirty minutes in large volumes of boiling acetone, it can be brought into solution, but it is precipitated again from the cold solvent. It is likewise negative for phosphorus (< 0·05 per cent phosphorus) and nitrogen (< 0·09 per cent nitrogen).

Upon alkaline hydrolysis with methanolic potassium hydroxide in the presence of benzene (80° C., 8 hr.) fraction *B* yields three different fractions: (1) neutral compounds and ether-soluble salts of acids; (2) ether-insoluble salts of acids; (3) a water-soluble part, containing the carbohydrates liberated by saponification.

After hydrolysis, fraction (2), which contains the acids, appears as an oily residue. This fraction shows the biological activity of the original material. It is obtained only in minute amounts.

Samples of lipopolysaccharides from tubercle bacilli[4] were kindly supplied to us by Drs. E. Lederer and J. Asselineau. Their material, which is insoluble in hot acetone, did not show the characteristic toxicity of our fraction *B*.

E. Sorkin
H. Erlenmeyer
H. Bloch

Department of Chemistry,
University of Basle,
and
Division of Applied Immunology,
Public Health Research Institute
of the City of New York, Inc.,
New York 9, N.Y. Feb. 6.

[1] Bloch, H., *J. Exp. Med.*, **91**, 197 (1950).
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Toxic Principle of *Lathyrus sativus*

The toxic substance of *L. sativus* responsible for lathyrism has been identified as selenium. *L. sativus* is much richer in selenium content than other pulses which are harmless (see table). Selenium has been estimated after wet incineration of the dried substance and reduction with ascorbic acid, which is a stronger reducing agent than hydroxylamine used by Klein[1]. Owing to the higher degree of utilization of *L. sativus* (Jiménez Díaz and Romeo[2] observed 86 per cent utilization) the high selenium content is easily transported to the tissues.

Pulse	Selenium content (mgm./100 gm. dry)
P. radiatus	2·5
P. sativum	1·2
C. arietinum	5·0
L. esculenta	2·3
L. sativus	22·9

Selenium has been given intraperitoneally to the monkey beginning with a dose of 500 μgm. and ending with 820 μgm. daily. In a period of eighty-four days, there were thirty-six blank days and forty-eight injections of a total of 31·23 mgm. selenium. After forty-one injections, extensor plantar (upturning of the hallux on stimulation) was first observed. The first sign of abolition of abdominal reflex was observed after forty-three injections. Flaccidity, the sign of ablation of area 4 [3], was also present. The upturned hallux after selenium administration in the monkey is very significant. The sign is produced in man and anthropoids when the pyramidal tract is interrupted; in the monkey, only when the entire cerebral hemisphere is removed[4]. Evidently selenium has not only caused degeneration of the pyramidal tract but has also produced more widespread lesions in the cerebral cortex. After the total dose of 31·23 mgm. of selenium, alkaline serum phosphatase was found to be increased to 90 King and Armstrong units[5], as compared to 14 units in the normal animal. Rudra and Bhattacharya[6] had previously observed that alkaline serum phosphatase is raised in lathyrism.

One of the mechanisms of action of selenium is by interference with methionine metabolism. In lathyrism patients who are still consuming the vetch pea, the methionine excretion falls to a fifth of the normal, the excretion rising to normal as soon as other pulses are substituted for the vetch pea[7]. Very early anorexia and gastrointestinal disorders are probably due to a disturbance in aneurin metabolism. Marked dermatitis may be due to some disorder in biotin utilization, since biotin is interrelated with fatty acid metabolism. We interpret these observations as due to selenium competing with sulphur. There is some indirect evidence that in lathyrism (due to selenium intoxication) the transmethylation process may be interfered with. Gillis and Norris[8] report that vitamin B_{12} helps the trans-methylation process. Rudra *et al.*[9] observed that motor neurone lesions in lathyrism patients are healed (extensor plantar becomes flexor; abdominal reflex) when methionine is given with vitamin B_{12}, while methionine given alone has no effect.

We are of opinion that selenium may interfere with enzyme systems requiring the sulphydryl or sulphamethyl groups for activity. The investigation is being continued.

We are indebted to the British Drug Houses, Ltd., for the gift of sodium selenite.

M. N. RUDRA

Department of Medical Chemistry,
Darbhanga Medical College,
Laheriasarai, Bihar.
April 24.

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Toxicity of Dextran in Rats

THE anaphylactoid reaction caused by dextran in rats has recently been studied by several investigators[1–3]. We have found that after intradermal injections of dextran dissolved in physiological saline (in rats), Menkin's intravenous dye test[4] shows a seepage of dye into the wheals when the concentration of commercial dextran (Macrodex, Pharmacia Inc.) is at least 10 μgm./ml. Moreover, it has been found that dextran preparations with highly branched molecular chains are more toxic than those with relatively unbranched chains. Dextran fractions of an average molecular weight of 10,000 cause a positive dye test only in concentrations of about 10 mgm./ml. Sulphuric acid esters of dextran[5] do not cause increased capillary permeability. We have confirmed the previously reported increase in hæmatocrit values after intravenous injection of dextran[3], and found that it is more or less completely prevented by antihistaminics, local anæsthetics and pretreatment with cortisone in high doses. The most potent inhibitor, however, is alloxan intravenously in a subdiabetogenic dose. 2,3-Dimercaptopropanol injected 30 min. before dextran has an inhibitory effect only in some experimental series. The factors causing these variations in the 'antiphlogistic' effect of *BAL* are under study.

T. EDLUND
B. LÖFGREN
L. VÄLI

Institute of Pharmacology,
University of Uppsala.
Jan. 2.

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Viability of *Conispiculum guindiensis* in *Calotes versicolor* Preserved in Formalin

SEVERAL specimens of *Calotes versicolor* (a garden lizard) were collected from gardens in Guindy near Madras, during March 1949. Blood, exuding from their cut tails, was examined for filarial infection. Six calotes found positive with microfilariæ of *C. guindiensis* were killed by the use of chloroform. Before preservation in formol–saline (one part of commercial formalin to four parts of normal saline) a 2-in. slit was made in the abdominal wall to open it. The specimens were brought to Delhi for demonstrating the adult worms *in situ*. In one specimen, which was dissected fourteen days later, although some degree of putrefaction had taken place, viable filarial worms were seen. Some of the adult female worms contained ova which stretched out to typical microfilarial forms. Similar findings were observed in the remaining calotes dissected at weekly intervals. The last two calotes were dissected in the sixth week of preservation. Temperature during that period ranged from 97·0° F. maximum to 51·0° F. minimum.

Similar results were observed in another batch of four calotes caught from the same area during March 1951. In yet another lot of four calotes, commercial formalin was used as a preservative, but all worms

were found dead within a week of preservation. This indicates that formol-saline, though it inhibited bacterial growth, did not kill the worms or the ova in them.

N. G. S. Raghavan

Malaria Institute of India,
Delhi.
Feb. 1.

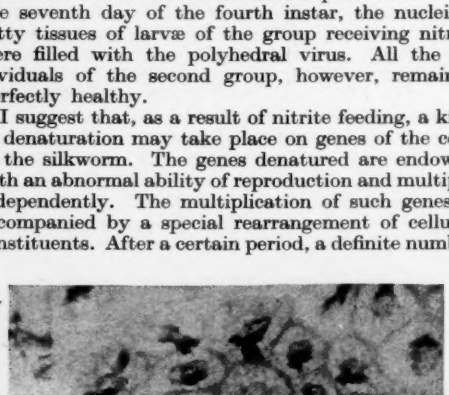
Effect of Nitrite on the Nuclear Structure in the Silkworm

It has already been observed[1] that nitrites caused the production of virus in the body of the silkworm. It is thus to be expected that changes of cellular structure in the worm may be provoked by nitrites. For the purpose of confirming this assumption, I have now conducted several experiments and prepared a large number of specimens.

In one experiment, I bred a virus-free strain in spring. On the first day of the fourth instar, larvæ were divided into two groups. The first group was fed with potassium nitrite once each day. The concentration of nitrite solution given was 2·8 per cent for the first three days, but it was later increased to 4·3 per cent. The second group was reared in an ordinary way. At regular intervals, the adipose tissues from worms of both groups were spread on glass slides, fixed in acetic acid – alcohol and stained with Delafield's hæmatoxylin.

It was found that cells of silkworms receiving nitrite showed abnormal morphological changes. The accompanying photograph is of a preparation made two days after the beginning of chemical feeding. In general, three kinds of abnormalities were observed: swelling of nuclei, aggregation of chromatins and amitosis. In caterpillars which had not received nitrite, the size of nucleus was much smaller, and I could not observe these anomalous phenomena. On the seventh day of the fourth instar, the nuclei in fatty tissues of larvæ of the group receiving nitrite were filled with the polyhedral virus. All the individuals of the second group, however, remained perfectly healthy.

I suggest that, as a result of nitrite feeding, a kind of denaturation may take place on genes of the cells of the silkworm. The genes denatured are endowed with an abnormal ability of reproduction and multiply independently. The multiplication of such genes is accompanied by a special rearrangement of cellular constituents. After a certain period, a definite number of independent genes combine together with rearranged components, and masses of extraordinary size—virus particles—are thus formed in nuclei. This seems a possible mechanism of chemical virus production.



Adipose tissue of silkworms fed on potassium nitrite. × 460

Kazuo Yamafuji

Agricultural Chemistry Institute,
Kyushu University,
Fukuoka, Japan.
Jan. 4.

[1] Yamafuji, K., *Nature*, **165**, 651 (1950). Yamafuji, K., and Yoshihara, F., *Enzymologia*, **14**, 124 (1950). Yamafuji, K., Akita, T., and Inaoka, M., *ibid.*, **14**, 164 (1950). Yamafuji, K., and Yoshihara, I., *J. Agric. Chem. Soc. Japan*, **24**, 388 (1951).

Some Effects of Ultra-violet Radiation on *Lemna minor*

In view of the fact that treatment with ultra-violet radiation has become a common technique in physiological and genetical work, the following observations we have made on the effect of ultra-violet radiation on *Lemna minor* may be of interest.

We used a 'Vitreosil' mercury vapour discharge lamp *T/M5/*369, which emits radiation mainly in the region of 2500 A. During irradiation the plants were floating on water in small beakers 20 cm. vertically underneath the lamp.

In the early experiments, the plants and the ultra-violet lamp were enclosed in a box during treatments. A strong smell of ozone developed in the box. Treatment for more than 10 sec. produced visible symptoms in the fronds, namely, the exudation of drops of liquid from the upper epidermis. Treatment for more than 30 sec. was lethal: the fronds lost their chlorophyll overnight and died in a few days.

Ultra-violet radiation was accompanied by the production of ozone. Accordingly we investigated the possibility that these symptoms were due to ozone in the atmosphere and not to the ultra-violet radiation *per se*. This possibility does not seem to have received attention in the literature on effects of ultra-violet radiation. Popp and Brown[1] do indeed mention experiments in which plants were exposed to "the ozone only" of the lamp; but they do not say whether there was any effect. To test the effect of ozone alone we left the ultra-violet lamp on for two minutes, with the box closed and empty. The lamp was then switched off, and the plants were put into the box without any ultra-violet radiation and were left in it for varying lengths of time. Under these conditions the same symptoms appeared after the same lengths of treatment as in the earlier experiments, although there was no ultra-violet radiation present.

In a third experiment *Lemna* plants were irradiated as in the first experiment, but two opposite walls of the box were removed and a strong current of air was blown over the surface of the plants to remove the ozone. Under these conditions the amount of irradiation which could be given in a single dose without producing visible symptoms was increased from 10 sec. to about 90 sec. The minimum lethal dose was increased from about 30 sec. to about 600 sec. The symptoms of damage by ultra-violet radiation are somewhat different from those due to ozone alone—for example, ultra-violet radiation without ozone does not cause rapid destruction of chlorophyll. During these final experiments we noticed that plants were affected by the ozone if they happened to be

in the same room, even when they were a few yards away from the source of radiation.

We conclude from these observations that if ultra-violet lamps are used in experiments with biological material, care must be taken to distinguish the effects of the radiation *per se* from those of the ozone produced by it.

E. Wangermann
H. J. Lacey

Department of Botany,
University College,
Leicester.

[1] *Bull. Torrey Bot. Club*, **60**, 161 (1933).

Identification of Tertiary Pollen Grains with those of New Guinea and New Caledonian Beeches

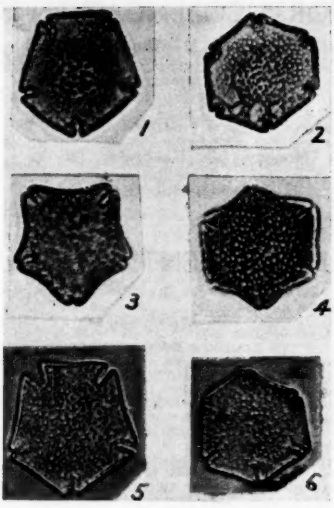
Several years ago, when certain pollen grains from Tertiary deposits in south-eastern Victoria were referred to the genus *Nothofagus*[1], it was recognized that some of them seemed to be intermediate in form between the two types of pollen grains that normally occur in this genus. At that time these divergent types were believed to be the pollen grains of extinct species of *Nothofagus*, and, as such, it seemed doubtful whether their exact affinity would ever be determined.

Examinations of the pollen grains of one of the New Guinea beeches, first discovered by Pulle in 1912 and independently recognized as *Nothofagus* by Brass and van Steenis in 1939, and of another beech discovered quite recently in New Caledonia by Dr. Baumann-Bodenheim, have shed light on the affinities of the fossil pollen. The pollen grains of both trees fall neither into the *menziesii* pollen group (*N. menziesii*, *N. cunninghami*, *N. moorei* and *N. obliqua*) nor the *fusca* group (*N. fusca*, *N. truncata*, *N. solandri*, *N. cliffortioides*, *N. gunnii* and, according to Cranwell[2], the bulk of the South American species) but are similar to the Tertiary pollen grains referred to by Cookson as *N.* sp. *e*.

This close agreement between the living and fossil pollen grains (Figs. 1–6) implying, as no doubt it does, a close affinity between the parents of each, indicates a long past-history and a far wider geographical distribution than at present. *N.* sp. *e*., which is probably the commonest of the Australian Tertiary pollen types, has been observed, sometimes in large numbers, in deposits that range from southern Queensland to Tasmania and westward into South Australia. Similar, if not identical, 'intermediate' pollen species have been distinguished in Cretaceous and Tertiary beds in New Zealand[3].

Several morphological and anatomical distinctions between the New Guinea beeches and other species of *Nothofagus* have already been observed by Langdon[4], who has remarked that "in certain respects they are sufficiently unlike the more typical members of that genus to justify their reference to a new section of the evergreen beeches". Their pollen morphology, so far as it is known at present, supports this statement.

Male flowers of the New Guinea species mentioned were collected by Mr. A. Schindler at Aiyura in the Eastern Highlands Division of New Guinea, and kindly forwarded to me by Mr. J. S. Womersley, forest botanist, Department of Forests, New Guinea.



(1) and (2) Acetolysed pollen grains of *Nothofagus* from Aiyura, New Guinea. × 600
(3) and (4) Acetolysed pollen grains of *Nothofagus* from New Caledonia. × 600
(5) and (6) Acetolysed pollen grains of *N.* sp. *e*. from Oligocene clay, Yallourn, Victoria. × 600

Anthers of one of the New Caledonian species were generously supplied by Dr. M. G. Baumann-Bodenheim, of the Botanical Gardens, Zurich.

Isabel C. Cookson

Department of Botany,
University of Melbourne,
Jan. 22.

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[2] Cranwell, L., *Rec. Auck. Inst. Mus.*, **2**, 175 (1939).
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[4] Langdon, L. M., *Bot. Gaz.*, **108**, 350 (1946–47).

Secondary Piliferous Layer in the Lupin

The communication by J. B. Goodey on a secondary piliferous layer in *Hippeastrum*[1] leads me to record a similar structure in *Lupinus*.

During the examination of seedlings of *Lupinus arboreus* grown in the laboratory, a yellow gelatinous layer was noticed to appear on the roots simultaneously with the emergence of root hairs. This layer was found to consist of the disorganized cells of the epidermis and the two outer layers of cortex. Root hairs had originated in the third layer of cortical cells and penetrated the outer layers of smaller cells either directly or after some distortion. No root hairs were seen arising from epidermal cells.

In culture, seedlings were not infected by nematodes; but plants growing in the wild on the drier parts of sand dunes were highly susceptible to attack. Seedlings in this habitat all had exceptionally heavy developments of root hairs.

P. A. Lush

Dominion Museum,
Wellington, C.3,
New Zealand,
Dec. 11.

[1] *Nature*, **167**, 822 (1951).

FORTHCOMING EVENTS

Monday, July 21—Thursday, July 24

Society for Applied Bacteriology (at Cambridge).—Summer Meeting and Annual General Meeting.

Thursday, July 24

Symposium on "Aspects of Food Preservation".

Monday, July 21—Friday, July 25

British Ecological Society (in the Department of Botany, University College, Southampton).—Summer Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Demonstrator in Geography—The Registrar, The University, Sheffield (July 25).

Director of the Research Establishment which the Board is setting up at Isleworth, Middlesex (the Establishment will be concerned with all underground activities connected with the mining of coal, and the principal qualifications for the post are proved ability in research in some branch of engineering or physics allied to engineering, and in directing teams of research workers)—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/499 (July 26).

Temporary Assistant Lecturer in Mathematics—The Principal, Royal Holloway College, Englefield Green, Surrey (July 28).

Analyst in the Chemistry of Insecticides and Fungicides Section—The Secretary, Long Ashton Research Station, Long Ashton, Bristol (July 31).

Lecturer in Chemistry (with special qualifications in physical chemistry)—The Registrar, University College, Cathays Park, Cardiff (August 9).

Technical Secretary (with a university degree in science or agriculture, or equivalent qualifications; previous administration and secretarial experience would be an additional desirable qualification) in the Division of Biochemistry and General Nutrition, University of Adelaide, Adelaide, to assist the Chief of the Division in matters relating to the administration of the Division, including preparation of reports, handling of technical inquiries, and technical correspondence—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3668 (August 9).

Lecturer (Grade II) in Civil Engineering, and a Lecturer (Grade III) in the Department of Physiology—The Registrar, The University, Birmingham 15 (August 11).

Research Fellowships in the Department of Electron Physics—The Registrar, The University, Birmingham 15 (August 12).

Assistant Professor of Biochemistry—The Chairman, Department of Biochemistry, Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada (August 15).

Lecturers in Experimental and Mathematical Physics—The Assistant Secretary of University Court, The University, Glasgow (August 15).

Senior Lecturer in Physics in the University of Natal, Pietermaritzburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 15).

Senior Lecturer in charge of the Department of Pharmacology, and a Lecturer or Assistant Lecturer in the Department of Physics, at the University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (August 30).

Assistantship in Physiology—The Assistant Secretary of University Court, The University, Glasgow (September 1).

Principal—The Clerk to the Governors, National Leathersellers College, 15 St. Helen's Place, London, E.C.3 (September 1).

Senior Lecturers (2, qualified architects and Fellows or Associates of the R.I.B.A., with considerable practical and teaching experience) in Architecture, at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 1).

Senior Lecturer or Lecturer in Physiology at Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (September 20).

Readership in Medical Parasitology at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 23).

Lecturer in Physics (with special qualifications in theoretical physics)—The Secretary, Queen's University, Belfast (November 30).

Assistant Agricultural Economist to undertake research and investigational work—The Registrar, Wye College, Wye, Ashford, Kent.

Assistant Biochemist (with a degree or equivalent qualification in chemistry) to undertake clinical biochemistry work—The Secretary, Welsh National School of Medicine, 34 Newport Road, Cardiff.

Assistant (Grade B) to lecture in the Department of Pharmacy and Biology—The Registrar, College of Technology, Suffolk Street, Birmingham 1.

Chemist in the Division of Atomic Energy (Production), at Windscale Works Sellafield, to be responsible for the supervision and operation of small-scale chemical plants processing radioactive materials—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 362.

Electrical Engineer in the Division of Atomic Energy (Production), to be responsible for the efficient upkeep and maintenance of the electrical plant in the production group of a large factory at Capenhurst, Chester—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 360.

Empire Rheumatism Council Fellowships (medical or scientific qualifications are needed) to prosecute research in the field of rheumatism—The General Secretary, Empire Rheumatism Council, Tavistock House (N), Tavistock Square, London, W.C.1.

Health Physics and Safety Group Manager (with a knowledge of radioactivity or electronics) in the Division of Atomic Energy (Production), to take charge of a group concerned with the investigation, measurement and control of radiation in a large nuclear chemical factory at Springfields, Salwick—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 357.

Honours Graduate in Physics, or related field, to work in Aberdeen on problems of smoking and drying of fish, including investigation of the physical properties of smoke and of the diffusion of water in fish—The Secretary, Herring Industry Board, 1 Glenfinlas Street, Edinburgh 3.

Lecturer in the Mechanical Engineering Department of the Municipal Technical College—The Chief Education Officer, Guildhall, Kingston-upon-Hull.

Lecturer in Physiology (honours graduate in physiology of a British university) for the Hygiene and Public Health Department—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

Microbiologist at the Colonial Microbiological Research Institute, Trinidad—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27059/324.

Physicist (with good honours degree) to be concerned initially with the processing of textile fibres, both from a practical and theoretical point of view; an interest in statistical methods is desirable, but not essential—The Secretary, British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

Post in the Physics Department (candidates should have a first- or second-class honours degree in physics) to assist in research on the properties of dairy products—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/8.

Research Assistantships (honours graduates with sound general training in either chemistry or physics) in the recently formed research group of the Department of Applied Science, Wolverhampton and Staffordshire Technical College—The Clerk to the Joint Education Committee, Educat on Offices, North Street, Wolverhampton.

Scientific Assistant (with a degree in a biological science related to the work of the Bureau, some ability in and interest in Bureau work, and some knowledge of various languages) for work in connexion with the abstracting, reviewing, and indexing of the literature dealing with veterinary science—The Director, Commonwealth Bureau of Animal Health, Veterinary Laboratory, Ministry of Agriculture and Fisheries, New Haw, Weybridge, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Report of the Pest Infestation Research Board with the Report of the Director of Pest Infestation Research for the Year 1950. Pp. iv+38+4 plates. (London: H.M. Stationery Office, 1952.) 1*s.* 9*d.* net. [75

Forestry Commission. Britain's Forests—Thetford Chase. Pp. 16. (London: H.M. Stationery Office, 1951.) 1*s.* net. [85

Forestry Commission. Forest Record No. 13: Chemical Control of Weeds in Forest Nursery Seedbeds. By G. D. Holmes and G. W. Ivens. Pp. 32. 2*s.* net. Forest Record No. 14: General Volume Tables for Japanese Larch in Great Britain. By F. C. Hummel, T. W. Irvine and J. Jeffers. Pp. 14. 9*d.* net. Forest Record No. 15: General Volume Tables for Douglas Fir in Great Britain. By F. C. Hummel, T. W. Irvine and J. Jeffers. Pp. 28. 1*s.* 6*d.* net. (London: H.M. Stationery Office, 1951–1952.) [85

Other Countries

Union Internationale de Chimie Pure et Appliquée. Comptes rendus de la Seizième Conférence, New York City et Washington, D.C., 8–15 Septembre 1951. Pp. ii+160. (Paris: Union Internationale de Chimie Pure et Appliquée, 1952.) [65

Anuario del Observatorio Astronómico de Madrid para 1952. Pp. 397. (Madrid: Instituto Geográfica, 1951.) [65

Geological Survey of Nigeria. Bulletin No. 21: Land Use and Soil Conservation in parts of Onitsha and Owerri Provinces. By A. T. Grove. Pp. viii+79+4 plates. (Lagos: Government Printer; London: Crown Agents for the Colonies, 1951.) 10*s.* 6*d.* [65

Companhia de Diamantes de Angola. Publicaçoes Culturais No. 12: Museu do Dondo? subsidios para o estudo da biológia na Lunda—Generalidades acerca da Lunda e da sua exploraçao biológica. Por A. de Barros Machado. Pp. 107. (Lisboa: Companhia de Diamantes de Angola, 1952.) [65

United States Department of Commerce: Coast and Geodetic Survey. Special Publication No. 135: Tidal Datum Planes. By H. A. Harmer. Revised edition. Pp. vii+142. (Washington, D.C.: Government Printing Office, 1951.) 60 cents. [75

National Academy of Sciences: Division of Geology and Geography, National Research Council. Publication 212: Report of the Committee on the Measurement of Geologic Time, 1950–1951. Pp. ii+146. (Washington, D.C.: National Research Council, 1952.) 1 dollar. [75

United States Department of Commerce: Weather Bureau. Technical Paper No. 16: Maximum 24-hour Precipitation in the United States. Prepared by Arthur H. Jenninga. Pp. iv+284. (Washington, D.C.: Government Printing Office, 1952.) 1.25 dollars. [75

Western Australia: Geological Survey. Bulletin No. 103: Part 1, Geology of portion of the Mt. Margaret Goldfield, by R. A. Hobson and Dr. K. R. Miles; Part 2, Garnetised Gabbros from the Eulaminna District, Mt. Margaret Goldfield, by Dr. K. R. Miles. Pp. 136. (Perth: Government Printer, 1951.) [85